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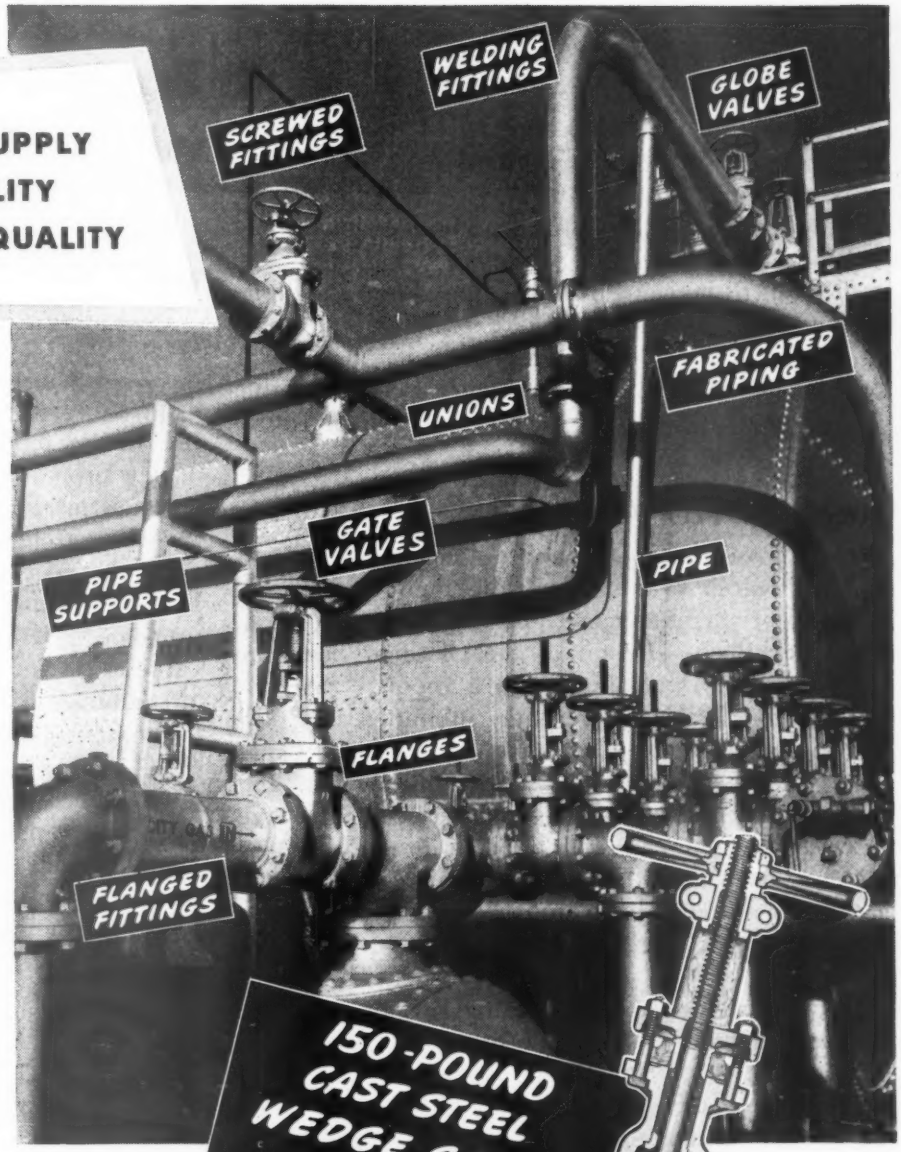

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The Course of Oil

by K. C. SCLATER

OIL INDUSTRY RESEARCH

That the oil industry is fully alive to the value of research is seen in the ambitious plans that several oil companies have announced for expansion of their research activities. Research sets the pace of technological progress in industry, where, in general, the trend toward intensive investigation is unmistakable. In the oil industry in particular, research is destined to play a greater and more vital role in postwar operations—a role far surpassing in scope and value that of prewar days. This augurs well for the future of the oil industry.

FULLER EMPLOYMENT SEEN

Among other benefits, well planned and coordinated research will lead to fuller employment and consequently create more jobs. In this connection, Vannevar Bush, director of the Office of Scientific Research and Development, in a report, "Science: the Endless Frontier," recently submitted to President Truman, stated that: "One of our hopes is that after the war there will be full employment, and that the production of goods and services will serve to raise our standard of living. We do not know yet how we shall reach that goal, but it is certain that it can be achieved only by releasing the full creative and productive energies of the American people.

"Surely we will not get there by standing still, merely by making the same things we made before and selling them at the same or higher prices. We will not get ahead in international trade unless we offer new and more attractive and cheaper products.

"Where will these new products come from? How will we find ways to make better products at low cost? The answer is clear. There must be a stream of new scientific knowledge to turn the wheels of private and public enterprise. There must be plenty of men and women trained in science and technology, for upon them depend both the creation of new knowledge and its application to practical purposes.

"More and better scientific research is essential to the achievement of our goal of full employment."

LAWS AFFECT RESEARCH

Industrial research is affected by the income tax law and by the patent laws, regarding which the report states: "One of the most important factors affecting the amount of industrial research is the income tax law. Government action in respect to this subject will affect the rate of technical progress in industry. Uncertainties as to the attitude of the Bureau of Internal Revenue regarding the deduction of research and development are a deterrent to research expenditure. These uncertainties arise from the lack of clarity of the tax law as to the proper treatment of such costs.

"The Internal Revenue Code should be amended to remove present uncertainties in regard to the deductibility of research and development expenditures as current charges against net income.

"Research is also affected by the patent laws. They stimulate new invention and they make it possible for new industries to be built around new devices or new processes. These industries generate new jobs and new products, all of which contribute to the welfare and strength of the country.

"Yet, uncertainties in the operation of the patent laws have impaired the ability of small industries to translate new ideas into processes and products of value to the nation. These uncertainties are, in part, attributable to the difficulties and expense incident to the operation of the patent system as it presently exists. These uncertainties are also attributable to the existence of certain abuses, which have appeared in the use of patents. The abuses should be corrected. They have led to extravagantly critical attacks which tend to discredit a basically sound system.

"It is important that the patent system continue to serve the country in the manner intended by the Constitution, for it has been a vital element in the industrial vigor which has distinguished this nation."

SCARCITY OF PERSONNEL

Liquid petroleum and natural gas are the raw materials for an almost limitless number of by-products, the development of which will be the task of company research departments and their personnel. Of competent personnel there is certain to be a scarcity for several years—this as an aftermath of the war. Despite this scarcity, the oil industry will engage in research on a greater scale than before in order to augment the stream of necessary new scientific knowledge.

In Dr. Vannevar Bush's report it is stated that "a nation that depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill." Likewise, it can be said of the oil industry that if it fails to apply new scientific knowledge its industrial progress will be retarded and its competitive position in domestic and foreign trade weakened, regardless of its mechanical skill.

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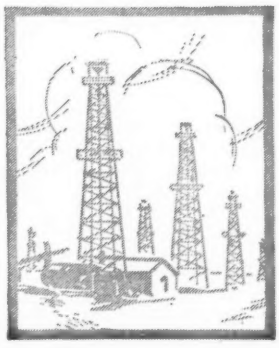

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Scanning WASHINGTON'S OIL HORIZON

WASHINGTON.—An opportunity to lay the platform for a national oil policy is open to Senator O'Mahoney, Wyoming, whose oil committee resumes its hearing about October 1.

Besides the important planks such as petroleum reserves, foreign oil, and synthetics, already discussed before the O'Mahoney Committee, there remain on the agenda: Crude oil requirements, the independent's place in the industry, and the disposition of government-owned pipe lines, tankers, and refineries.

PAW is planning to shut down the Big Inch and Little Big Inch pipe lines as soon as tankers take over, which will be in a matter of weeks. A water piston will push out the line-fill and then the lines will be turned over to RFC for disposal. Their proposed use for natural gas is bound to provoke opposition from coal miners and operators.

Disposal of the tankers probably will await enactment of the ship sales bill now pending in Congress.

RFC has worked out an interim leasing arrangement for the refineries. A number have been leased to the operators for 90 days under this formula: Take 70 per cent of the actual cost of the facilities that the operator can use in his peacetime operations, then figure rentals on an annual basis of either (1) 5 per cent for operation at any percentage of capacity or (2) a graduated scale depending on actual operations, such as 6 per cent for 80 per cent of capacity ranging down to 3 per cent for 40 per cent of capacity operation.

To provoke the fullest discussion of disposal plans, the O'Mahoney Committee sent out letters soliciting suggestions to members of the oil, gas, and coal industries; federal, state, and local government agencies; railroads; co-operatives; labor unions; and other parties likely to be interested.

● **WARTIME CONTROLS.** PAW has rolled up the barbed wire so fast that it has drawn protests from some members of the industry who had previously been contending for relief from government regimentation. Very few controls will be left by October 1 but it may be the end of the year before PAW's doors are closed, So long as there is any vestige of the Petroleum Administration left, PAW wants to continue its industry advisory committees, including the Petroleum Industry War Council, whose next meeting has been postponed until October 17.

● **OPA.** Oil price control is likely to continue for some months yet. And, believe it or not, some oil men are veering around to the idea that they want price ceilings continued for a while. This is due to OPA's announced intention of not removing price controls until the supply is ample to hold prices down—in other words, until the market has softened. So, these oil men fear the psychological effect on the price structure when OPA removes ceilings.

OPA favors continuance of the stripper well subsidy so long as crude oil prices are controlled. Meanwhile, some oil country congressmen are already considering introduction of bills to make the stripper well subsidy a matter of permanent government policy.

● **ICKES.** Interior Secretary Ickes can be expected to retire from the Cabinet as soon as the Anglo-American oil agreement, now being renegotiated in London, is safely through the Senate and PAW is folded up.

● **SYNTHETIC RUBBER.** Long range, the Truman Administration is committed to a program of continued research and development of synthetic rubber as a safeguard against another war cutting off the natural supply. Whether petroleum or alcohol will get first call as the raw material for synthetic rubber, isn't clear yet. Alcohol is much more expensive but, say the politics-conscious observers, the farmer is going to be subsidized one way or the other so it might as well be through alky-rubber. (This overlooks the fact that the petroleum industry may be able to produce synthetic alcohol much cheaper.)

Meanwhile, Rubber Reserve Company is beginning to wonder about its butylene supply for petroleum butadiene with the future of many catalytic cracking plants still undecided. Many refiners may want to use their butylenes in gasoline. It has been suggested that some government-owned 100-octane facilities, which might otherwise be shut down, could be converted to making butylenes for synthetic rubber. Rubber Reserve has had some conversations along this line with operators of two government-owned dehydrogenation plants.

● **SUPPLY AND DEMAND.** Postwar military requirements have not been finalized yet and the pattern for civilian demand, freed of rationing restrictions, is still shaping up, but using the yardsticks at hand it has been roughly estimated that worldwide demand for petroleum products during the next six months may approach 7,000,000 bbl. per day. (This may be on the high side because of unpredictable factors—automobile use, for example. Prewar per vehicle consumption has been figured in, although tires and worn-out parts may hold down the average.)

Excluding Russia, East Indies, and some other areas for which data are not available, worldwide production of crude and condensate on the basis of a 7,000,000-bbl. demand for products will be 6,880,000 bbl. per day during the last quarter of 1945 and first quarter of 1946. This is broken down, as follows: U. S. production: Crude oil, 4,600,000 bbl. per day; condensate, 340,000 bbl. per day. Foreign production: Crude oil, 1,900,000 bbl. per day; condensate, 40,000 bbl. per day.

Worldwide refining operations, on the same basis, must average 6,900,000 bbl. per day, broken down as follows: U. S. refinery runs, 4,600,000 bbl. per day; transfers, 420,000 bbl. per day. Foreign: Refinery runs, 1,840,000 bbl. per day; transfers, 40,000 bbl. per day.

These estimates contemplate heavy drafts on military stocks as well as changes in other stocks.

Under these projections, the estimated daily average of foreign production of crude and refinery operations by countries, through the first quarter of 1946, are:

	Production, Bbl. per day	*Refining, Bbl. per day*
Caribbean Area	1,050,000	800,000
Iraq	90,000	
Iraq, India and Inland Iran		12,000
Egypt	25,000	25,000
Iran	375,000	360,000
Saudi Arabia	70,000	60,000
Bahrein Island	20,000	*60,000
India	7,000	
Mexico	115,000	110,000
Peru	40,000	40,000
Haifa		80,000
Other South American	69,000	78,000
Canada	22,000	150,000
Europe	17,000	65,000
Total	1,900,000	1,840,000

*When expansion is completed.

● **POSTSCRIPTS.** Oil imports coming into the U. S. during recent months have averaged about 250,000 bbl. per day; it is expected they will continue at about that rate for sometime.... Secretary Ickes says he doesn't object any longer to the Department of Justice going ahead with its omnibus anti-trust suit, pending since 1940, against the American Petroleum Institute and 300 oil company defendants—but Attorney General Clark has his doubts about going to trial with the suit, at least in its present form, because of changed conditions.... Navy expects to have its petroleum pools at New York, Norfolk, and Houston drained by October 31, except for 100-octane; Pacific Coast pool will be continued for sometime yet.... Backed by PAW, the industry has renewed its claim for $22,655,000 paid in war risk insurance prior to April 20, 1942, when the government took over tanker operations; decision is up to OPA Chief Bowles.

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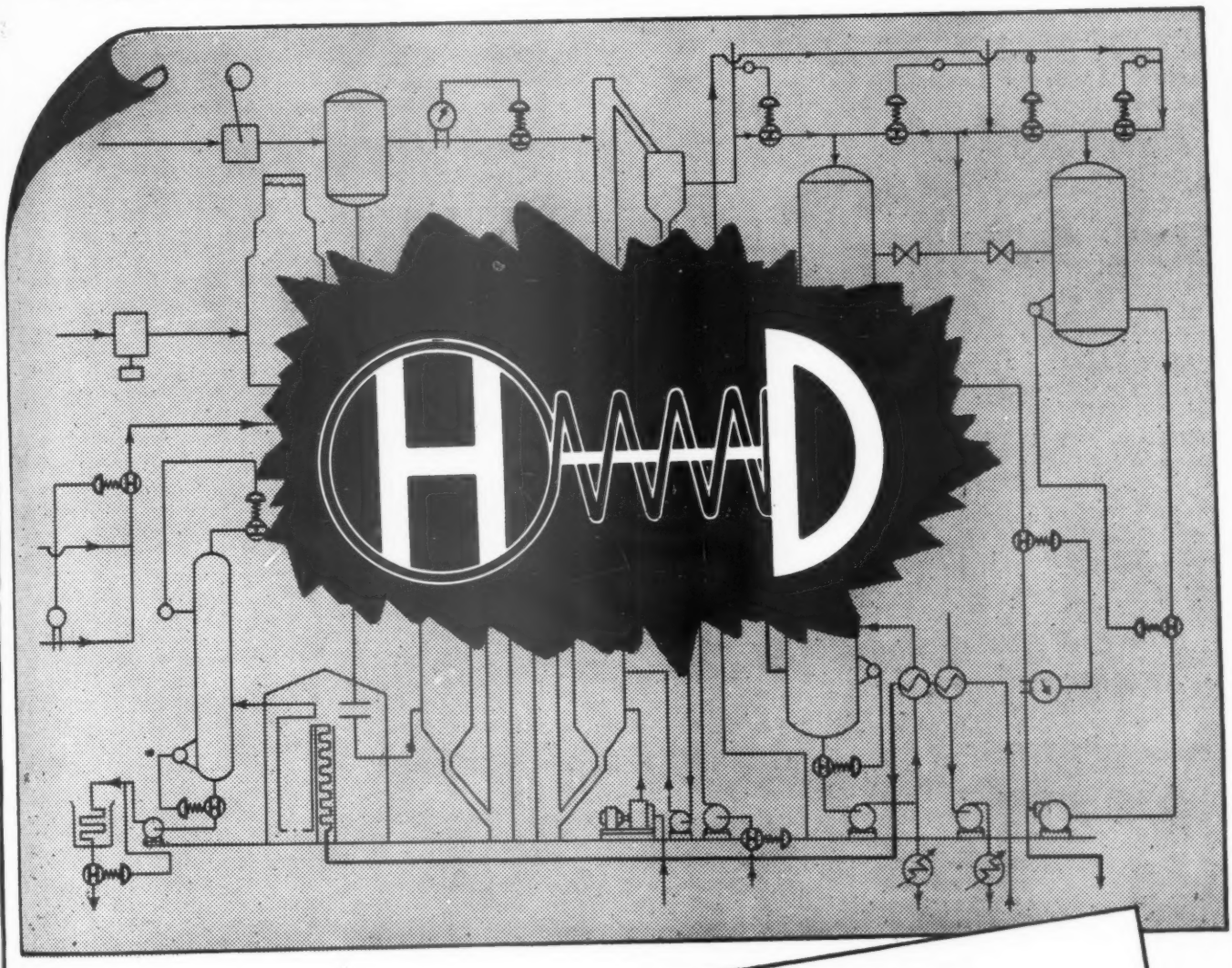

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NATIONAL PETROLEUM SITUATION

TEXAS, CALIFORNIA CUTS IMMINENT. Texas and California will bear the brunt of cut-backs in crude oil production. War's end means 1946 is first post-war year, which must bear severe reduction in crude output. Texas allowable for September was cut 395,588 bbl. daily, which is about one-half of the ultimate reduction in output expected by first quarter of next year. California has begun cut-backs in crude output, which are likely to reach a net loss by next year of 200,000 bbl. daily.

AUGUST CRUDE OUTPUT OFF. Production of crude oil in August dropped to 4,887,000 bbl. daily, against 4,941,000 bbl. in July. California showed the greatest decline, with a drop of 33,000 bbl. daily. September and subsequent months, well into first quarter of 1946, will reflect reconversion with continued reductions in output. Areas that produce above efficient rates will pave the way to substantial cut-backs. Examples are Southwest and East Texas which were slashed 27 per cent and 17 per cent respectively in September.

DRILLING HOLDS UP WELL. Cumulative drilling results are not far behind the goal set for this year. Through August the industry drilled a total of 17,659 new wells, compared with a quota to date of 17,982. However, wildcat drilling continues to lag. Wildcats drilled in first 8 months were 2710, against a cumulative quota of 3329. Lack of an adequate price for crude has been a deterring factor in exploratory operations. Yet it is significant that results this year are about 8 per cent better than last year.

REAPPRAISE STOCK POSITION. While stocks have been heavily drawn upon during the war period, and have been considered subnormal for many months, it is necessary now to reappraise the industry's over-all stock position. On the basis of war demands combined stocks of crude and products are about 12 per cent below working requirements. Yet, in the light of reconversion to peace-time needs, which are expected to be subnormal well into next year, stocks must be measured in terms of substantially reduced requirements. Subsequent months are expected, therefore, to reveal a greater adequacy of inventories through smaller demand divisors which will lengthen the days of supply on hand.

MISSISSIPPI IN SPOTLIGHT. Mississippi has shown outstanding performance this year. Drilling operations are 194 per cent above last year, while wildcat operations have shown a gain over last year of 57 per cent. At the same time, daily crude production of this state has shown an increase of 19 per cent. Daily crude output in Mississippi during August was 53,000 bbl., against 45,000 bbl. a year ago. The state completed 34 new wells in August, against only 4 a year ago.

Comparative Statistics, August, 1945

*All figures are computed on a Bureau of Mines basis**

	August 1945	July 1945	August 1944	This year to date	Last year to date	Per cent change
Wells drilling	4,100	4,150	4,210	4,100	4,210	— 3
Total wells drilled	2,346	2,532	2,086	17,659	14,002	+26
Development wells	2,007	2,168	1,713	14,949	11,499	+30
Oil	1,219	1,293	1,161	9,149	7,980	+15
Gas	213	248	186	1,630	1,356	+20
Dry	575	627	366	4,170	2,163	+93
Per cent dry	28.6	28.9	21.4	27.9	18.8	+ 9.1
Wildcat wells	339	364	373	2,710	2,503	+ 8
Oil	35	54	40	358	300	+19
Gas	15	14	9	94	78	+21
Dry	289	296	324	2,258	2,125	+ 6
Per cent dry	85.3	81.3	86.9	83.3	84.9	— 1.6
Crude production	151,500	153,175	145,296	1,174,477	1,100,140	+ 7
Daily average	4,887	4,941	4,687	4,833	4,509	
Crude demand†	162,160	160,689	149,765	1,231,795	1,138,763	+ 8
Daily average	5,231	5,183	4,831	5,069	4,667	
Crude stocks	217,705	222,730	230,192	214,050	230,192	— 7
Days supply	42	43	48	40	48	
Natural gasoline production	9,930	9,975	8,792	76,030	66,487	+14
Daily average	320	322	284	313	272	
Motor fuel production	71,450	71,760	64,064	543,834	483,654	+12
Daily average	2,305	2,315	2,067	2,238	1,982	
Gasoline yield, per cent	40.4	40.8	39.4	40.4	38.9	+ 1.5
Motor fuel demand	70,200	69,985	66,657	541,260	481,264	+12
Daily average	2,265	2,315	2,150	2,227	1,972	
Motor fuel stocks	81,200	79,600	70,753	81,200	70,753	+15
Days supply	36	34	33	36	33	
Fuel oil production	64,350	62,820	57,884	492,432	463,999	+ 6
Daily average	2,076	2,026	1,867	2,026	1,902	
Fuel oil demand	57,470	57,330	54,957	534,368	480,938	+11
Daily average	1,854	1,849	1,773	2,199	1,971	
Fuel oil stocks	86,790	74,575	94,218	86,790	94,218	— 8
Days supply	47	40	53	47	53	
Refinery still runs	155,650	154,875	143,047	1,181,961	1,096,341	+ 8
Daily average	5,021	4,996	4,614	4,864	4,493	
All refined stocks	251,980	231,260	245,390	251,980	245,390	+ 3
Days supply	50	46	51	50	51	

*Unless otherwise stated all figures represent thousands of barrels.
†Domestic and foreign. ¶Revised.

Crude Prices by States for August, 1945

Eight months ending August, 1945

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	17,982	17,659	98
Production (daily crude output)	5,084	4,833	95
Refining (daily still runs)	4,914	4,864	99
Stocks (crude and refined)	528,866	466,030	88
Price of crude (per bbl.)	$1.99	$1.22	61

Crude Prices by States for August, 1945§

U. S. average	$1.22	Louisiana	$1.20
Texas	1.23	Arkansas	1.25
California	1.07	New Mexico	1.04
Oklahoma	1.17	Mississippi	1.10
Kansas	1.17	Illinois	1.37
		Other states	1.89

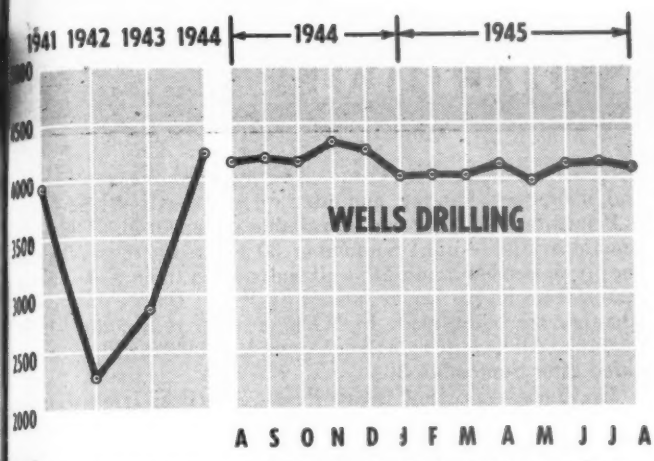
Basic crude prices

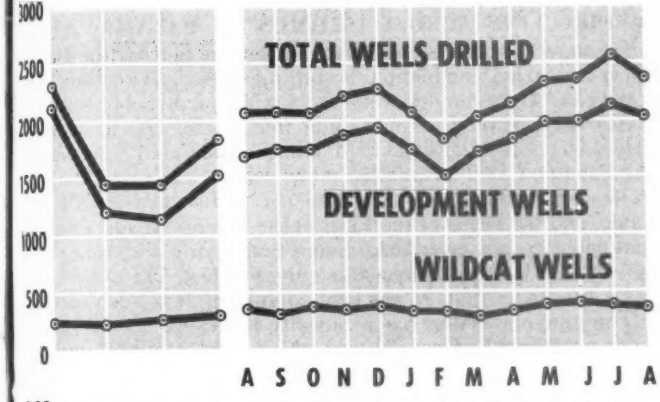
Oklahoma-Kansas (36 gr.)	$1.17
Texas Gulf Coast (36 gr.)	1.40
East Texas	1.25
West Texas (36 gr.)	1.04
Calif. Signal Hill (26 gr.)	1.11
Pennsylvania Bradford	3.00

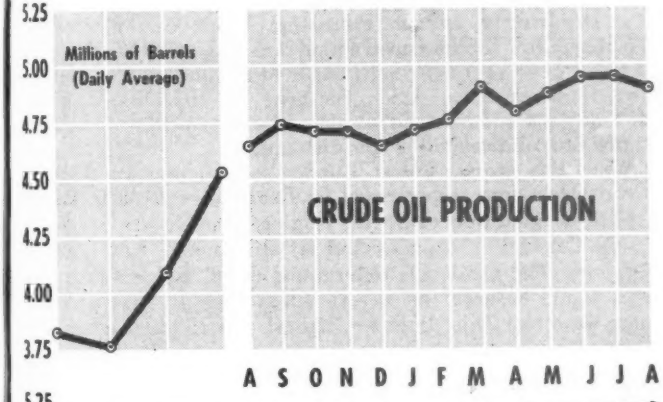
Drilling and Production Statistics by States

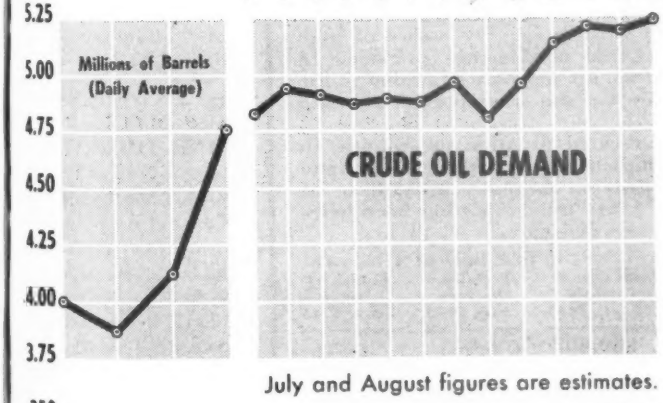
	August 1945	July 1945	August 1944	This year to date	Last year to date	Per cent change
Total wells drilled	2,346	2,532	2,086	17,659	14,002	+ 26
Texas	595	633	565	4,714	3,605	+ 31
California	206	207	168	1,567	1,285	+ 22
Oklahoma	191	229	155	1,593	1,051	+ 52
Kansas	158	155	171	1,115	1,195	— 7
Louisiana	85	89	71	722	491	+ 47
Arkansas	16	19	41	111	207	— 46
New Mexico	29	31	29	277	263	+ 5
Mississippi	34	32	4	238	81	+194
Illinois	177	166	171	1,137	1,129	+ 1
Other states	855	971	711	6,185	4,695	+ 32
Wildcats drilled	339	364	373	2,710	2,503	+ 8
Texas	119	142	136	1,052	900	+ 17
California	24	24	12	162	143	+ 13
Oklahoma	52	35	32	312	229	+ 36
Kansas	36	28	46	253	335	— 24
Louisiana	12	19	6	116	85	+ 36
Arkansas	0	3	12	25	46	— 46
New Mexico	9	6	6	50	45	+ 11
Mississippi	16	11	5	88	56	+ 57
Illinois	32	39	44	228	242	— 6
Other states	39	57	74	424	422	0
Daily crude production	4,887	4,941	4,687	4,833	4,509	+ 7
Texas	2,212	2,206	2,130	2,176	1,992	+ 9
California	919	952	859	921	836	+ 10
Oklahoma	388	388	338	377	333	+ 13
Kansas	268	269	272	268	271	— 1
Louisiana	350	355	355	354	352	+ 1
Arkansas	79	80	83	80	80	0
New Mexico	102	103	105	104	110	— 5
Mississippi	53	51	45	51	43	+ 19
Illinois	207	215	211	208	213	— 2
Other states	309	322	289	294	279	+ 5

§No change since prices frozen. Prices do not include subsidies.
(p) Preliminary. ***Does not include input wells.

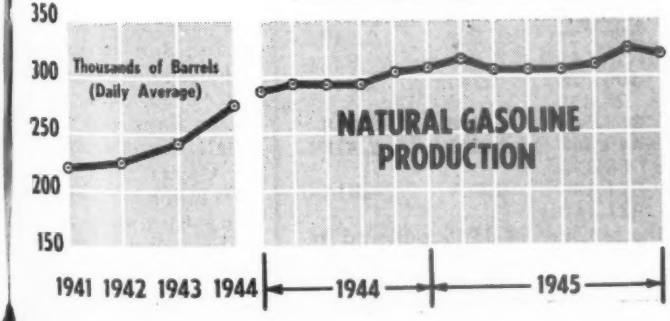


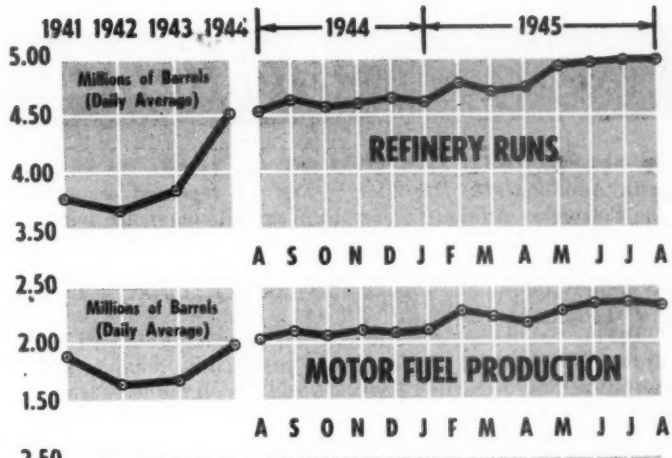


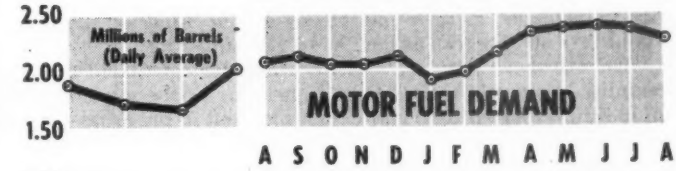


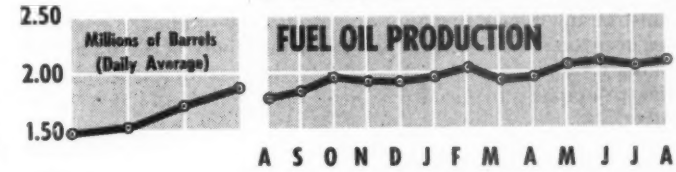


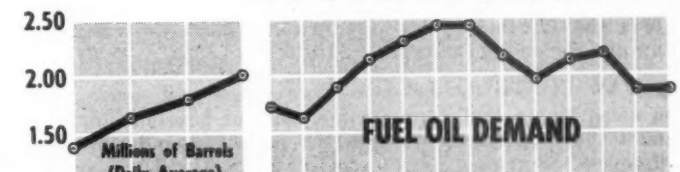
July and August figures are estimates.



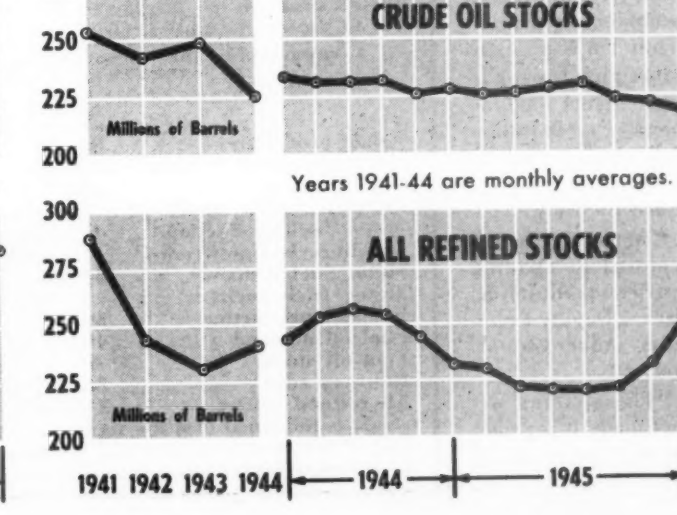








Years 1941-44 are monthly averages.



Highlights IN OILDOM

● **SEES END TO PAW BY LAST OF YEAR.** "In keeping with Administrator Harold L. Ickes' oft repeated assurance, the Petroleum Administration for War will commence immediately the liquidation of its affairs with a view to closing the agency at the earliest possible date." This is a statement made by Deputy Petroleum Administrator Ralph K. Davies soon after V-J Day.

Davies stated that existing wartime controls would be withdrawn as rapidly as possible in the production, refining, transportation, and marketing branches and the oil industry freed to operate upon a normal peacetime basis.

Many orders, he said, could be immediately canceled, but others involving merged operations of one kind or another would take some weeks or months to wind up.

"We will move promptly, but in a manner calculated to accomplish a smooth and efficient transition. In the case of the oil industry, there is no reconversion required in the usual sense of the word," the deputy administrator said.

"Various production, refining and distribution adjustments must be made now that unit operation of the industry ceases to be necessary. But, in general, the same kinds of products are being produced today as are required in peacetime; the change lies principally in the direction of contraction and rearrangement."

In reply to queries for an estimate as to the length of time required to wind up the work of the office, Davies said: "My guess would be that we can wind up all the barbed wire between now and the end of the year."

● **PAW CONTROLS LIFTED.** Controls on well spacing and on construction in the production, natural gasoline, refining, and transportation branches of the petroleum industry were eliminated September 1.

Action was taken by the revocation of three wartime materials and construction limitation orders and their supplements: Petroleum Administrative Order 15, Petroleum Administrative Order 8, Petroleum Administrative Order 11 (formerly Order M-68) and 16 supplementary orders to PAO-11.

PAO-15 governs transportation and refinery construction. PAO-8 and PAO-11 govern oil, gas, and condensate well spacing, special production operations, gasoline plant construction.

All administrative letters, field orders, and other directions issued by the Petroleum Administration for War governing well-spacing patterns, drilling limitations and designation of restricted areas are also canceled.

It is no longer necessary for operators to obtain permission from PAW to construct pipe lines, gasoline plants, and refineries, or to follow well-spacing patterns previously established by PAW.

Commenting on the removal of spacing restrictions, Ralph K. Davies, Deputy Petroleum Administrator, said:

"The spacing orders made it possible for the industry to meet the war's unprecedented demand for crude oil with a minimum use of material, manpower, hauling, and other oil well services."

Priorities assistance made available under Order P-98-b will remain available until September 30 to assure the industry a supply of needed material at all times, even though the uses of material no longer are regulated by PAW, Davies announced. Changes are being made by WPB in order to accomplish this purpose. All priorities assistance under P-98-b will be terminated after September 30.

Mr. Davies said that Order P-98-e, which assigns priorities assistance for the acquisition of petroleum equipment by persons other than petroleum operators, had been revoked.

● **PIPE LINE ACROSS ISTHMUS OF PANAMA.** A pipe line across the Isthmus of Panama to assure fuel for the Pacific Fleet is nearing completion, according to the Navy's Bureau of Yards and Docks under whose supervision it is being built.

The original purpose of the pipe line was to serve as a supply artery from the Atlantic to the Pacific, in the Canal Zone, should the Panama Canal have fallen to the enemy. The pipe line, even in its earliest stages, proved so efficient and so strategically valuable, and the needs of the Fleet in the Pacific became so great, that capacity was more than doubled by laying additional lines even before the first system was quite finished. The entire project is now more than 95 per cent completed, it is announced.

The pipe-line system has a capacity of 265,000 bbl. of fuel oil a day, 60,000 bbl. of gasoline, and 47,000 bbl. of diesel fuel.

The original conception of the pipe line took form in August, 1942, as a joint project of the Chief of Naval Operations, the War Department, and the Petroleum Administration for War. Responsibility for its construction was delegated to the Chief of the Bureau of Yards and Docks, Vice Admiral Ben Moreell, Civil Engineer Corps, USN. The goal was 105,000 bbl. of fuel oil a day for one line and another pipe line with a capacity of 35,000 bbl. of diesel oil or gasoline a day.

When this project was still under construction, the Chief of Naval Operations, represented by Rear Admiral A. F. Carter, USNR, decided to broaden the original plan. It was decided to double the fuel oil capacity and lay still another line for gasoline only. The previously determined diesel and gasoline pipe lines would be used for diesel fuel exclusively. Consequently, there were two 20-in. lines for fuel oil, one 12-in. gasoline line, and one 10-in. diesel oil line. The original pipe line was completed in October, 1943.

● **ANNOUNCES 600-MILE PIPE LINE JOB.** Officials of the Great Lakes Pipe Line Company, Kansas City, Missouri, announce that 600 miles of 8-in. pipe will be laid beginning October 1 to enlarge its system. The project includes a 200-mile line from Barnsdall, Oklahoma, to Kansas City, and an extension from Kansas City to Omaha and Sioux City, Iowa, and Sioux Falls, South Dakota.

Oscar Dempsey, Oklahoma Contracting Company, and Midwestern Constructors have been awarded contracts.

P. E. data very close to actual statistics

The National Petroleum Situation has made another record of high accuracy. Its figures for the first six months of this year, published in the July issue of *The Petroleum Engineer*, are a striking parallel to the United States Bureau of Mines statistics for the same period, released September 1.

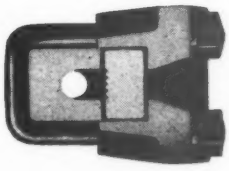
The difficulty of estimating a complicated situation two months in advance has been increased by the complete censorship of import and export data. In spite of this, *The Petroleum Engineer* breakdown of the oil situation has displayed an insight into trends that has been helpful to those who must keep ahead of recorded data.

Comparison of the two sets of figures for the first half of 1945 are:

	Petroleum Engineer July, 1945	*Bureau of Mines Sept., 1945*	*Petroleum Engineer July, 1945*	*Bureau of Mines Sept., 1945*
	Cumulative		Daily Average	
Crude production	871,457	869,802	4,815	4,806
Crude demand	900,464	928,157	4,975	5,127
Crude stocks	226,172	223,262	.....	.....
Natural gasoline production	56,462	56,125	312	310
Motor fuel production	402,950	400,624	2,226	2,213
Gasoline yield, per cent	40.8	40.4	.....	.....
Motor fuel demand	406,662	400,778	2,247	2,214
Motor fuel stocks	77,825	78,812	.....	.....
Fuel oil production	368,804	365,262	2,008	2,018
Fuel oil demand	401,961	419,568	2,221	2,318
Fuel oil stocks	66,,885	68,048	.....	.....
Refinery runs	868,689	871,436	4,799	4,814
All refined stocks	215,620	221,189	.....	.....

It is indicated that the figures for the last half of 1945 gathered by *The Petroleum Engineer* will be even closer to the actual statistics because more information is available upon which to estimate the figures.

Alike in Quality



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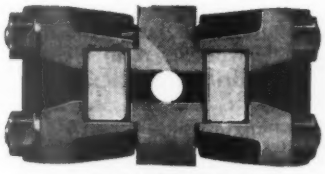

PENBERTHY
Transparent
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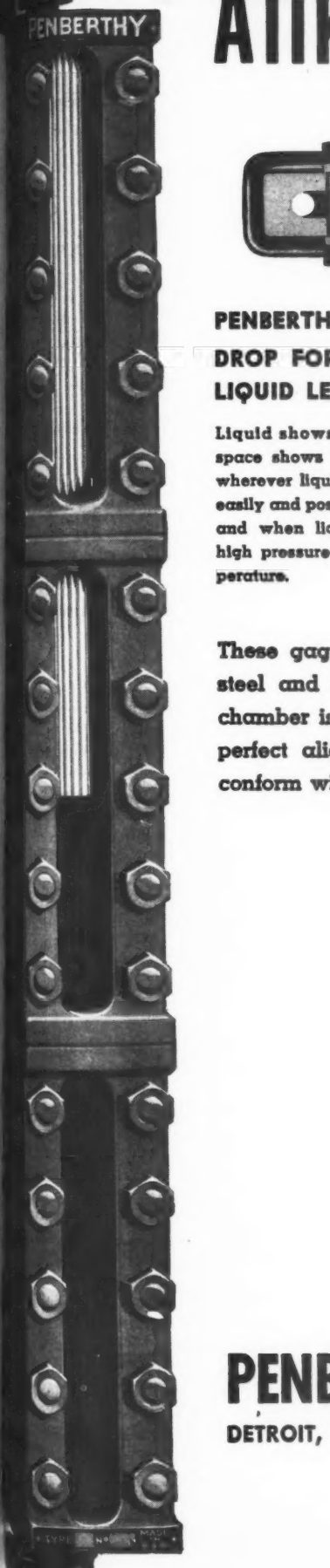

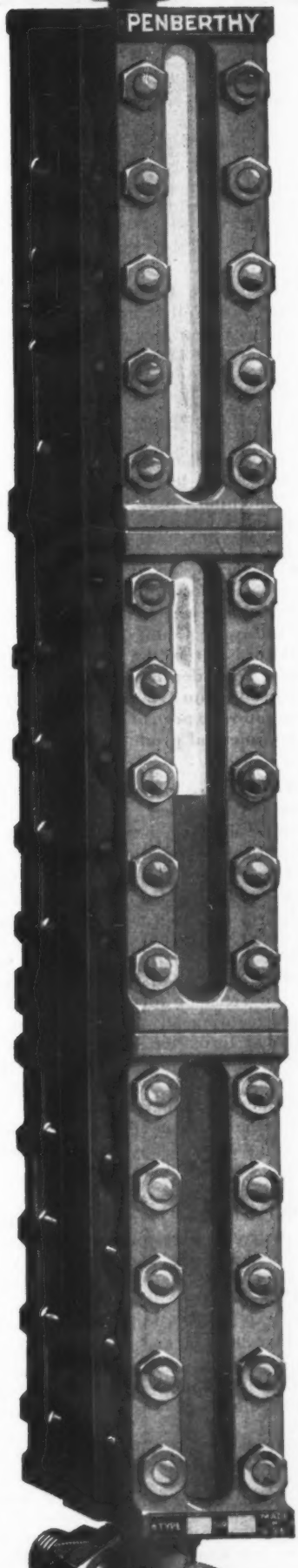

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PENBERTHY PRODUCTS

MAJOR *Oil Field* ACTIVITIES

● **ILLINOIS.** Carter Oil Company's 1-A well on Provident Mutual Insurance Company's lease 2 miles east of the Bungay pool, Wayne County, is a new pool opener. It made 126 bbl. of oil and 6 bbl. of water after a 50-qt. shot. The well is 7 miles northeast of McLeansboro, NW NW SE, 14-4s-7e. Total depth is 3327 ft. with the producing zone from 3286-3318 ft.

The Texas Company's No. 1-A Bowyer test well 3 miles northwest of Wayne City near Keens, Wayne County, shows for a good commercial oil well and opens an extensive new area for development. It is 3 miles from substantial oil production. The well, SE SE NW, 34-1s-5e, is being watched closely. The Aux Vases is found from 2974-81 ft. On a 24-hr. test it made 228 bbl. of oil. A pumping unit is being installed for an official completion test.

● **ARKANSAS. The Barnsdall Oil Company and associates have opened a new gas condensate pool in Lafayette County, southwestern Arkansas. It is the No. 1 Moore Heir. Total depth is 9321 ft., with oil production from 9300-9319 ft. Operators expect to complete it as a commercial producer.**

● **WYOMING.** Kerlyn Oil Company, Carter Oil Company, and Phillips Petroleum Company have brought in a producer in Wyoming that proves up the deeper zone of the Sheldom Dome structure. The well, No. 1 Shoshone, C NE NE, 16-5n-2w, is 50 miles north of Lander, Fremont County, in the northern part of the state. The well flowed 50 bbl. of oil per hour on test from the Tensleep formation at 6974 ft. After cementing off and perforating in the Embar formation, it flowed an average of 50 bbl. an hour for 5 hours in that formation. There is an estimated 100 ft. of productive Embar formation to be tested. Operators believe four sections are proved by the new producer. Total acreage of the block is 5270.

● **OKLAHOMA.** J. E. Crosbie, Inc., and Warren Petroleum Corporation have opened a new pool for the Cromwell sand area, Paden district, Okfuskee County. The discovery is No. 1 Novotny, NE SE SW, 20-12-7e. It was drilled to 3844 ft. and made 30 bbl. of oil in 20 minutes, but subsided due to cavings. Operators finally cleaned out and shot the hole. Tests are not completed.

Gulf Oil Corporation No. 1 Briscoe Estate CSE NW 36-2-8w, Stephens County is a new gas condensate pool discovery for that area. It flowed natural gas at a rate of 15,000,000 cu. ft. with the potential calculated at 40,000,000 cu. ft.

Continental Oil Company No. 1 Butterly NW SW NE, 14-1-1, Garvin County, swabbed 93 bbl. of oil in 12 hours on initial tests to open a new pool for the area. Total depth is 4422 ft. in the Arbuckle lime. Operators have not finished swabbing and cleaning.

Pontotoc County has a pool opener with Ashland Oil and Refining Company No. 1 Hales, NE NE NW, 11-4n-7e. It is south of Francis in the northern part of the county and is giving that area a spirited revival. Total depth is 2062 ft. with production from the Gilcrease at 2056-62 ft.

No. 1 Lee, a new Wilcox sand pool in the area east of Shawnee, Pottawatomie County, enhances the petroliferous prospects for the region and opens a new pool for the area. The Texas Company is the operator. The wildcat topped the Wilcox at 4711 ft. and showed stain and porosity at 4760-75 ft. On drillstem test it recovered 16 ft. of oil-cut mud. Operators were continuing to drill.

● **WISCONSIN.** Wisconsin Oil Refining Company, Sheboygan, Arthur Williams, Ithaca, and Clifford Collin, Mount Pleasant, all in Michigan, have brought in a well on a large block in Elba Township, Gratiot County. The strike opens a new pool for the state. The well, Cook 1, SW SE SW, 14-9n-1w, averaged 10 bbl. of oil per hour from 2438 ft. Oil was found in the top of the Traverse formation and it is believed that deeper sections of the Traverse will be productive. The wildcat is only half a mile from a test drilled in 1927 that produced 25 bbl. a day but was later abandoned when 4 offsets were drilled dry.

● **MISSISSIPPI. No. 1 Smith, Jefferson County, opens a pool for Mississippi. Humble Oil and Refining Company is the operator of the new deep pool. The discovery is producing at the rate of 8.35 bbl. of 36-gravity oil per hour through casing perforations opposite a pay zone from 9730-36 ft. The wildcat was drilled to 11,299 ft. Production is from the Tuscaloosa formation. The well is about 5 miles from LaFayette and is the fifteenth pool for the state.**

● **KANSAS.** No. 2 Petrie, of British American Oil Producing Company, NW SW SW, 36-26-1w, opens a new pool for Sedgwick County. The well is a short distance northwest of Wichita and 4 miles south of the Valley Center pool, nearest production. It carries an initial rating of 417 bbl. of high-gravity oil a day from the Simpson formation at 3387-92 ft. The discovery is expected to start a new drilling play in the county.

Continental Oil Company and Cities Service Oil Company have given Sheridan County a new pool with No. 1 Hoxie State Bank, NE NE NE, 32-8-26w, 2 miles southwest of the Studley pool. Production is from the Lansing-Kansas City lime and initial rating is 280 bbl. of oil a day.

A possible pool opener for Ellis County is Darby and Bothwell, Inc., and others' No. 2 Cromb, NE NW NW, 22-11-20w. The well is 6 miles southeast of the Marcotte oil pool of Rooks County. After finding black oil in the Arbuckle, operators plugged back to the Lansing lime and perforated casing. Considerable oil of high-gravity rose in the hole.

● **ALABAMA. Carter Oil Company No. 1 Sam Almna, Choctaw County, southwestern Alabama, opens a new pool 3 miles east of Gilbertown, original discovery for the Yellowhammer state. Total depth of the well is 3376 ft. with production in the Eutaw between 3367-76 ft.**

● **TEXAS.** Gulf Oil Corporation has opened a new Permian lime oil pool in southwestern Crane County. The well is No. 2-E Henderson. It is approximately 3 miles southwest of the Tubb pool. The discovery flowed 190 bbl. of oil naturally in 10 hr. with the producing zone from 4380-4445 ft. The company plans to treat the lime zone with acid before completing.

Skelly Oil Company-Warren Petroleum Corporation has opened a new pool in Colorado County with No. 1 R. Hamel Estate. The well flowed 194 bbl. of 46.3-gravity oil per hour with 1,338,734 cu. ft. of gas. Production was from 9052-69 ft.

Humble Oil and Refining Company No. 1 F. T. Reitz has opened a new pool in Wharton County south of El Campo. It flowed at the rate of 41 bbl. of 61-gravity condensate with 3,640,000 cu. ft. of gas.

The Beckville area, Panola County, has a new gas condensate pool opener at Skelly No. 1 Bead-Norman unit. Production is from the upper Pettit, 6020-52 ft., and the lower Pettit, 6185-6210 ft. Testing has not been completed.

A new 6100-ft. gas condensate field in Brooks County has been opened by Humble No. 1 Skipper. The wildcat flowed 11.25 bbl. of 63.2-gravity condensate and 895,000 cu. ft. of gas a day.

Magnolia Petroleum Company No. 1-B Tucker, southwestern Crane County, indicated production from the Waddell zone of the Simpson, middle Ordovician, by flowing clean oil through the drill pipe during the last 3 minutes of a 46-min. test. The production is from 5774-5801 ft. and the well is located 3 miles from the nearest Waddell pay.

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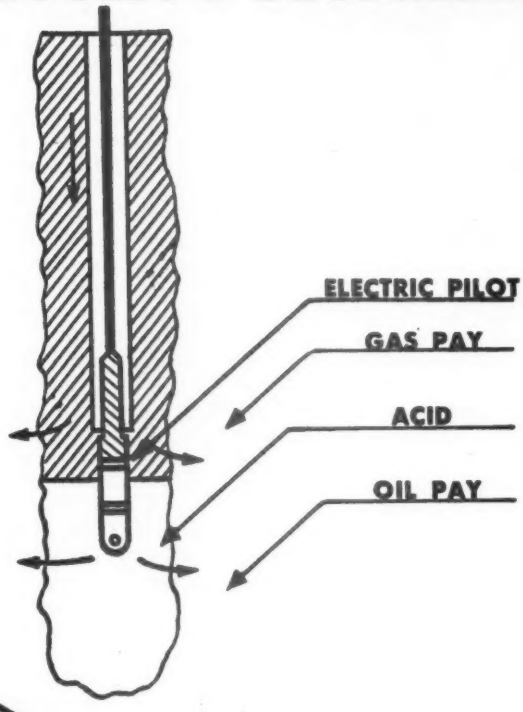

Selective Acidizing . . . with the Dowell Electric Pilot . . . results in greater production because the acid is directed into the formation where it will give the greatest benefit.

This robot engineer . . . the Electric Pilot . . . stands guard during the treatment. It registers the acid level on a surface meter enabling the Dowell engineer to pump the chemicals to the exact zone chosen for treatment.

Use the Dowell Electric Pilot in wells that have been deepened to new pays or where high gas-oil or water-oil ratios exist; where two or more pay zones are exposed or where sand is found near limestone.

Call the nearest Dowell station for Selective Acidizing service and don't forget to ask for your free copy of the booklet describing the Electric Pilot and its uses.

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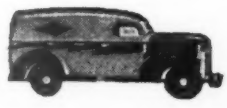


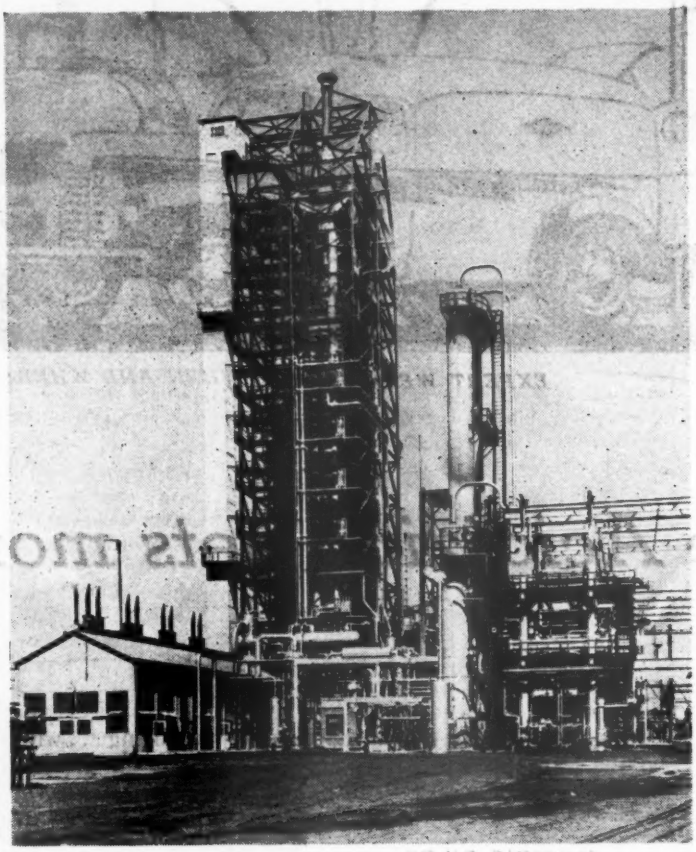
Selective Acidizing

Other Dowell Services and Products: The Electric Pilot, Mud Acid Treating, Plastic Service, Chemical Scale Removal, Paraffin Solvents, Jelflake and Inhibited Hydrochloric Acid.

Look to
DOWELL
FOR OIL INDUSTRY CHEMICAL SERVICE

MAJOR *Refining* ACTIVITIES

● **RECONVERSION FEAT.** Without lay-off of workers, Tide Water Associated Oil Company has converted its Houdry and thermofor catalytic cracking gasoline refinery plant at Bayonne, New Jersey, from the manufacture of 100-octane aviation gasoline for war airplanes to the production of Tydol Flying-A gasoline for civilian automobile use, it has been announced by B. I. Graves, vice president in charge of the Eastern division of the company. The relaxation of production restrictions on civilian car and truck fuel by PAW has made it possible for the company already to deliver the prewar-type gasoline to its wholesale and retail outlets throughout the entire Eastern section of the country.



Tide Water Associated Oil Company's modern thermofor catalytic cracking unit at Bayonne, New Jersey.

"The rapid conversion of our huge new catalytic cracking units at Bayonne, New Jersey," said Graves, "has released a flood of motor fuel of the high quality and performance that will in the immediate future help to eliminate all danger of shortages for those who travel in automotive vehicles. The completion of this plant contributed importantly to the production of high-octane gas for the armed services and its immense capacity is now available to all Eastern motorists."

The company's cracking equipment at Bayonne consists of two units, one employing the Houdry process of catalytic cracking and the other the Thermofor catalytic cracking process through which were produced 100 and 91-octane aviation gasoline stock, butane butylene fractions, and Navy diesel fuel oil for the war. These plants are now turning out civilian autmobile gasoline. The thermofor catalytic cracking unit, which was created by the conversion of two of the company's thermal cracking units, has increased Tide Water Associated's production of aviation gasoline components by 60 per cent. Both these new units were built at the company's expense without aid from the government.

● **VENEZUELA UNIT.** Creole Petroleum Corporation has announced plans to construct a $2,500,000 stabilization plant in Jusepin field, eastern Venezuela. The plant, which will require 14 months to build, will increase Creole's richest eastern Venezuela field by 1500 bbl. daily through removal of gasoline fractions from waste field gases, the company said. It also will control the salt content of the field crude and return 10,000,000 cu. ft. of gas a day to wells at pressure to maintain production rates, said J. A. Clark, assistant manager. Creole is a crude oil producing subsidiary of Standard Oil Company of New Jersey.

● **POSSIBLE PLANT.** Indications are that Gulf Refining Company may be planning a Mississippi plant to make natural gasoline from gas produced at the Heidelberg and Eucutta fields. A continuation of the upward swing in production together with the discovery of a new field made the talked-of project likely.

● **FOUR HUMBLE UNITS.** Humble Oil and Refining Company has been authorized to build four gas conservation projects costing $3,500,000 and designed to conserve for productive use 56,000,000 cu. ft. of natural gas daily. The projects involve five fields in the Gulf Coast—West Clear Lake, Friendswood, Anahauc, and Lovell Lake fields in Texas and the North Crowley field in Louisiana. Natural gasoline plants will be built at West Clear Lake and Anahuac and compressor stations will be installed at Lovell Lake and North Crowley. The plant at West Clear Lake will process daily 5,000,000 cu. ft. from Clear Lake, 20,000,000 cu. ft. from Friendswood, and 6,000,000 cu. ft. from the Dickinson-Gillock field. This plant is expected to recover from the gas 25,000 gal. of liquid products daily. The plant at Anahuac will have a capacity to process 12,000,000 cu. ft. of gas daily and recover 5400 gal. a day of liquid products. The Lovell Lake project involves the installation of additional compressors in order to gather 4,500,000 cu. ft. of gas daily and to boost the pressure so that gas may be delivered to a transmission line that is already connected with the field.

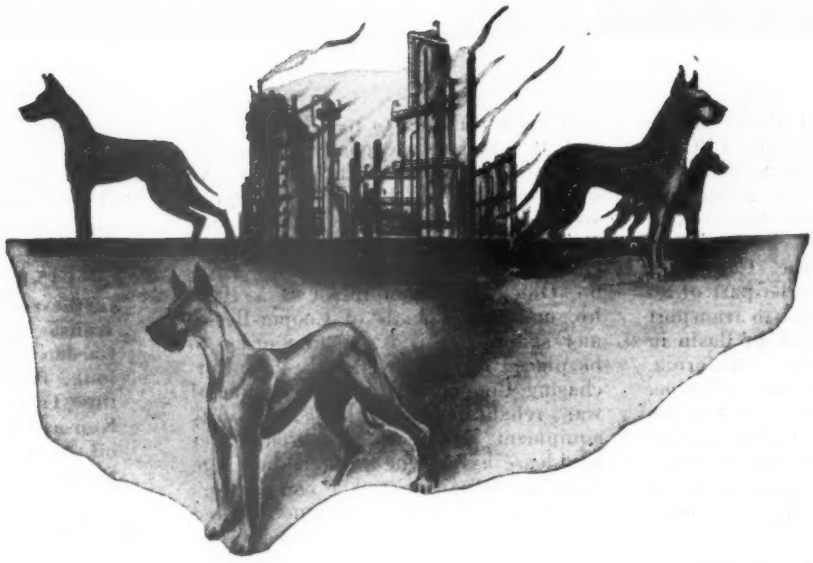
● **PHILLIPS AT PEACE CAPACITY.** All Phillips Petroleum Company's wartime manufacturing plants are operating at capacity to produce peacetime products, Frank Phillips, chairman, and K. S. Adams, president, have announced.

"The day government restrictions were lifted," they said, "our operations were shifted to making a new motor fuel, the best we have ever produced. The improved product is already in the tanks of many of our jobbers and dealers." Facilities built for producing 100-octane are being used to manufacture higher antiknock, more powerful motor gasoline.

Reconversion was effected with no lay-offs of refinery personnel and jobs are awaiting all 2864 employes on military leave, the announcement said.

● **TO BUILD TERMINAL.** Cities Service Oil Company has applied for a building permit to erect a marine terminal on Byllesby Avenue, Green Bay, Wisconsin. Total investment is expected to be about $125,000. Facilities will include 9 small storage tanks for various petroleum products and a spur track and driveway for railroad car and truck deliveries. The terminal will have a 4,000,000-gal. capacity.

● **CONTRACT FOR PLANT.** Stanolind Oil and Gas Company has let contract for a natural gasoline and cycling plant in the Hastings pool of Brazoria County, south Texas, to Stearns-Roger Manufacturing Company of Denver, Colorado. The project will cost an estimated $4,500,000. It will have a capacity of 30,000,000 cu. ft. of gas daily with an estimated output of 750 to 1000 bbl. of natural gasoline daily. It is expected to take about a year for completion.



Watch Dogs of the Refinery

The many UOP services protect the plant investment and refinery operations of its licensees.

CATALYTIC CRACKING	*THERMAL CRACKING*	*RETREATING*
CATALYTIC REFORMING	*THERMAL REFORMING*	*POLYTREATING*
HYDROGENATION	*HYDROFORMING*	*U. O. P. CATALYSTS*
ALKYLATION	*DEHYDROGENATION*	*UNISOL TREATING*
ISOMERIZATION	*POLYMERIZATION*	*U. O. P. INHIBITORS*

Universal Oil Products Co.
Chicago 4, Ill., U. S. A.

UOP

Petroleum Process Pioneers
For All Refiners

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MAJOR *Pipe Line* ACTIVITIES

● **720-MILE LINE.** El Paso Natural Gas Company has filed with FPC an application for permission to construct and operate a 720-mile natural gas pipe line from Lea County, New Mexico, and other fields on the east bank of the Colorado River to Blythe, California. The line is designated to be part of an immediate postwar project to transport natural gas from the Permian Basin in West Texas to southern California, through more than 900 miles of pipe. El Paso is expected to be joined in the undertaking by Southern California Gas Company, subsidiary of Pacific Lighting Corporation, although commitment of the California company has not been confirmed.

● **WORK BEGUN. Construction has begun on United Gas Pipe Line Company's 143-mile, 24-in. carrier from the Carthage field, Panola County, East Texas, to Monroe, Louisiana. Plans call for completion by January 1. The line is to cost $7,261,000.**

● **RATE REDUCED.** RFC has announced a reduction in rates for transporting petroleum products through the Big Inch and Little Big Inch war emergency pipe lines to a rate equivalent to current war shipping tanker rates. The agency will charge an additional 14.7 cents per bbl. for shipment of crude from the East Texas fields to Gulf refineries, 14.1 cents from Southwest Texas crude, and 26 cents for West Texas crude to meet gathering costs.

● **PERMISSION SOUGHT.** Cities Service Gas Company is seeking permission to build additional pipe line facilities between Welda and Ottawa, Kansas. An official for the company said that the end of the war will have no effect on natural gas consumption in Kansas and Missouri, the states that the line would serve. George V. Rowland, commercial manager of the company, said the new artery would increase gas supplies to Topeka, Atchison, Leavenworth, Kansas City, and Lawrence, Kansas, and St. Joseph, Sedalia, Independence, and Kansas City, Missouri. The company has two 16-in. lines operating between the two pumping stations and asks permission to lay a 20-in. third line. If permission is granted by FPC, Rowland predicted the line could be in operation by the winter peak consumption season.

● **PIPE LINE FOR RUSSIA.** The first Big Inch natural gas pipe line to be built in Russia will be equipped with American compressors. The line will extend from the city of Saratov in the Ural Mountain gas producing section to the capital at Moscow, a distance of more than 500 miles. The line will have as its primary purpose the transportation of natural gas to supply domestic and industrial fuel to the Russian capital. It will have a capacity of approximately 80,000,000 cu. ft. per day. An order for 24 CMV, 10-cylinder compressors has been placed by the Russian Purchasing Commission with The Cooper-Bessemer Corporation, Mount Vernon, Ohio. Each compressor is a 1000-hp. unit and officials of Cooper-Bessemer said that this is the first order to be placed directly by the Russian Purchasing Commission in its program of war rehabilitation. Other heavy-duty equipment has been purchased under lend-lease agreement through the U. S. Treasury Department. The compressors will be installed in 6 stations situated along the pipe line, each to be equipped with four of the American-made units. The line will be capable of handling a pressure of approximately 800 lb. per sq. in. This puts it in the category of a high-pressure line.

● **PERMISSION TO BUILD GRANTED.** Gulf Refining Company, pipe line division has received permission from PAW to enlarge by looping its sweet crude transportation facilities from the West Texas Permian Basin to Port Arthur on the Gulf Coast. Plans call for the laying of 481 miles of new 10-in. line at an estimated cost of $7,000,000. The new work will increase capacity by 30,000 bbl. a day. New pumping equipment also will be added.

Contracts have been awarded to Oklahoma Contracting Company, Dallas, Texas, Associated Contractors and Engineers, Houston, Texas, and J. R. Horrigan Construction Company, Houston.

● **TO LAY LINE. The Arkansas-Louisiana Gas Company has made arrangements to provide an outlet from the Harleton field in northwest Harrison County, Texas. The company will build an 18-mile, 8-in. artery from the field to Daingerfield, Morris County, Texas. Pipe is available and the survey already has been made, company officials said.**

● **BELL LINES.** Bell Oil and Gas Company has begun laying a 35-mile pipe line and gathering system from the Aylesworth area and the Mead pool, Marshall County, to the Ben Franklin refinery at Ardmore, all in Oklahoma. Ben Franklin Refining Company, Bell subsidiary, has a gathering system in both producing districts and has been gathering the oil to a central station at Little City, where it has been trucked to Ardmore. Pipe is now ready and the first sections of the line will be laid from the fields to Madill, from where oil will move by tankcar to Ardmore until additional pipe has been received to complete the line. The company estimates the entire project will take about 6 weeks. The two fields are considerably larger than originally expected and pipe line facilities are said to be urgently needed. The new line also will provide Bell with adequate oil for its Ardmore operations, officials said.

● **LINE COMPLETED. The farthest west crude oil pipe line in Kansas has been finished near Garden City. It is about 12 miles long, is owned and operated by the Trans-Crude Company of Kansas City, and was built to pipe oil to a refinery company near Shallow Water, Kansas.**

● **PRICE CONTRACTS.** The H. C. Price Company, Bartlesville, Oklahoma, has been awarded the following contracts: For Shell Pipe Line Corporation: Take up, recondition and relay 30 miles of 10-in. oil line from Cushing, Oklahoma, northeast to the Arkansas River; for Empire Southern Gas Company: Lay 40 miles of 8-in. gas line near Andrews, Texas; for Oklahoma Natural Gas Company: Take up 26 miles of 12-in. gas line and lay 26 miles of 12-in. gas line from Chickasha to Stroud, Oklahoma. Construction is beginning immediately on the Shell and Empire Southern projects. The Oklahoma Natural project will be started in October.

● **IRAQ CONTRACT.** A contract to supply 120,000 tons of 16-in. pipe for Iraq Petroleum Company's pipe line from Kirkuk, Iraq, to Haifa, Jerusalem, has been awarded the firm of Stewarts and Lloyds, Ltd. It is believed to be the largest such order ever placed in the United Kingdom. Preliminary work on the line has begun and it is scheduled for completion in the spring of 1946. The line is planned to boost output in the Kirkuk fields to a maximum of 10,000,000 tons annually from the present 4,000,000. Exploration has been resumed in the Basrah concession where drilling operations, by agreement, start two years from now. In October and December two parties of American technicians are to arrive and set about completing the project.

● **RECONDITION LINE.** Bell-Western Corporation has awarded a contract to United Contracting Company of Wichita Falls, Texas, to recondition the 4½-in. main pipe line from the Fargo and Odell fields of Wilbarger County, Texas, east across the Red River and through Tillman County, Oklahoma, to the Bell refinery at Grandfield, Oklahoma. The line will be completely raised, cleaned, coated, and wrapped and will be equipped with cathodic protection and insulating flanges to prevent excess corrosion and electrolytic action in that area. The line is the sole artery carrying oil from the fields.

THE Petroleum Engineer

SEPTEMBER, 1945

OLD OCEAN REFINERY BUILT ESPECIALLY FOR PRODUCTION OF AVIATION GASOLINE

NUMEROUS refineries throughout the United States played an important role during the war in the manufacture of aviation gasoline. In most cases, at the time the program was instituted, additions were made to existing refineries to equip them for the manufacture of 100-octane gasoline. The plant of J. S. Abercrombie Company and Harrison Oil Company, situated in the Old Ocean field near Sweeny, Texas, however, was one notable exception. Constructed by the companies mentioned as agents for Defense Plant Corporation and operated as lessees without profit, this refinery is the only one to be built by DPC from the ground up and equipped specifically for aviation gasoline production.

EXCLUSIVE

The plant was built at a time when there was still the possibility that congested refinery areas on the Gulf Coast might be bombed by the Axis powers. For that reason it was thought advisable to erect a plant inland, yet close to ready crude oil supply. The result was the refinery in the Old Ocean field, and due to the fact that it was constructed specifically for the making of aviation gasoline, the percentage of 100-octane fuel processed compared to crude charge is outstanding. The overall yield figure for July was 38 per cent Grade 130 aviation gasoline. In addition to this fuel other products include motor gasoline, diesel fuel oil, No. 2 furnace oil, and residual fuel oil.

The principal divisions of the refinery are the crude oil unit, thermal reforming unit, fluid catalytic cracking unit, alkylation unit, and a butane isomerization unit.

● **Crude oil unit.** Charge to the crude oil unit is 25,000 bbl. a day of essentially 42-gravity oil composed largely of Old Ocean mixed crude with some Coastal type crudes added to produce a greater volume of gas oil. The mixed crude is first charged to an 8-ft. by 63-ft. flash tower. End point of the flash tower overhead is 250°F., which comprises the front 13-15 per cent of the crude charge. This flash tower overhead material is the charge for a 5-ft. by 93-ft. depentanizer column, the bottom product of which is 91-octane base stock. This straight run stock has a vapor pressure of approximately 4 R.v.p., a 1-C octane rating of 91, and a 3-C rating of approximately 97.5 $\frac{S.}{M}$ Flash tower bottoms are charged to the atmospheric tower, the overhead of which has a 195°F. initial boiling point and a 400°F. end point. This material comprises approximately 31 per cent of the crude oil charge and is the charge for the naphtha reforming unit. The atmospheric tower is 48 ft. 2 in. in overall height.

Outstanding percentage of 100-octane gasoline compared to crude oil charge processed at Sweeny, Texas

The top section of the tower is 14 ft. 6 in. I.D. and the lower section 8 ft. 8 in. I.D. From the side of the atmospheric tower is drawn a light gas oil cut ranging from 400°F. initial to 730°F. end point. Bottoms from the tower are charged to a vacuum tower, which is 33 ft. high overall, the top section being 10 ft. I.D. A gas oil cut having an initial of approximately 500°F. is taken off the side, crude residue being drawn from the bottom of the tower. The crude residue comprises approximately 75 per cent of the Bunker C or residual fuel oil.

Light gas oil from the atmospheric tower is mixed with the heavy gas from the vacuum tower to provide charge for the fluid catalytic cracking unit.

The crude oil unit produces approximately 2200 bbl. of 91-octane base stock, 8000 bbl. of straight run heavy naphtha, 12,000 bbl. of mixed gas oil, and 2000 bbl. of residual fuel oil.

● **Thermal reforming unit.** The thermal reforming unit charges 7800-8000 bbl. a day of straight-run heavy naphtha, producing as its primary product a stabilized reformed gasoline, which is the principal component of premium gasoline, and as a secondary product a B-B pentane-amylene stream for alkylation charge stock.

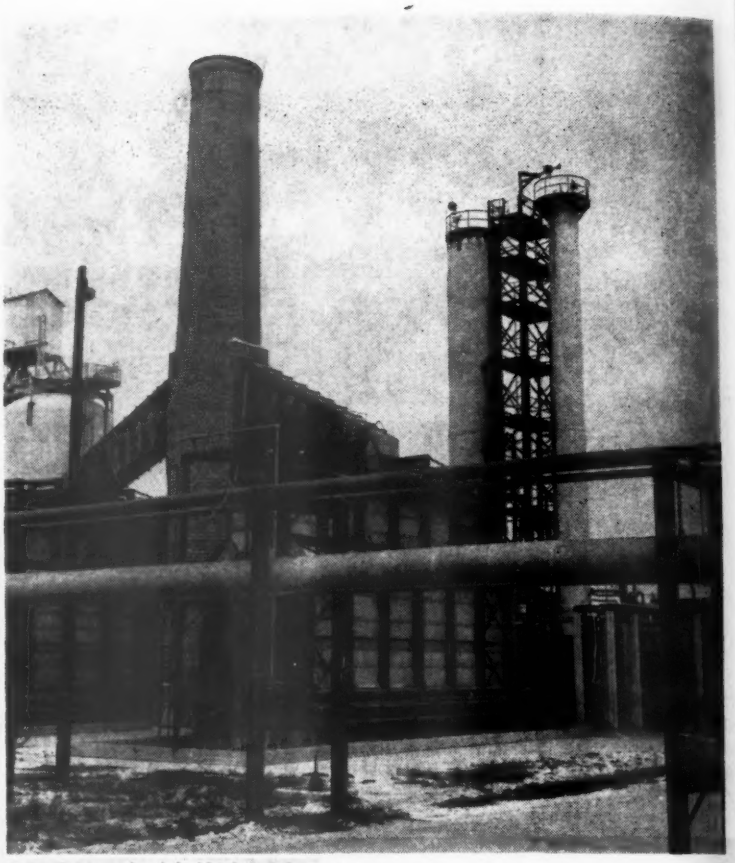
The heavy naphtha charge is received from the atmospheric tower of the crude

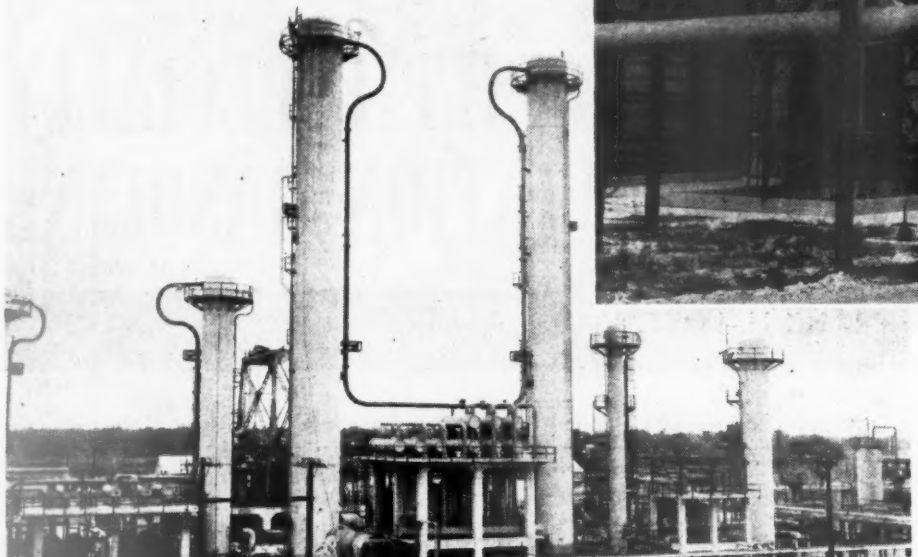
unit. The charge has an initial boiling point of approximately 190°F. and an end point of approximately 400°F. This naphtha is reformed at a furnace pressure of 300 lb. and a transfer temperature of about 1070°F.

The B-B pentane-amylene stream produced constitutes approximately 17 per cent of the naphtha charge. The reformed gasoline stream is about 55 per cent of the naphtha charge, and the residue is about 5 per cent. This residue is blended with the residue from the crude oil unit to form residual fuel oil.

Depentanized reformed gasoline is pressured to approximately 8-lb. R.v.p., which produces 75-octane premium grade gasoline clear. The B-B pentane-amylene stream is charged to the alkylation unit together with catalytic B-B pentane-amylene from the fluid catalytic cracking unit.

The reformer fractionating column is 9 ft. in diam. by 67 ft. high. The absorber-deethanizer, which is a part of the reforming unit, is 5 ft. in diam. and 72 ft. 4 in. high. This latter tower handles all propane and lighter material from the reformer, as well as approximately 8,000,000 cu. ft. a day of light gases from the catalytic cracking unit.



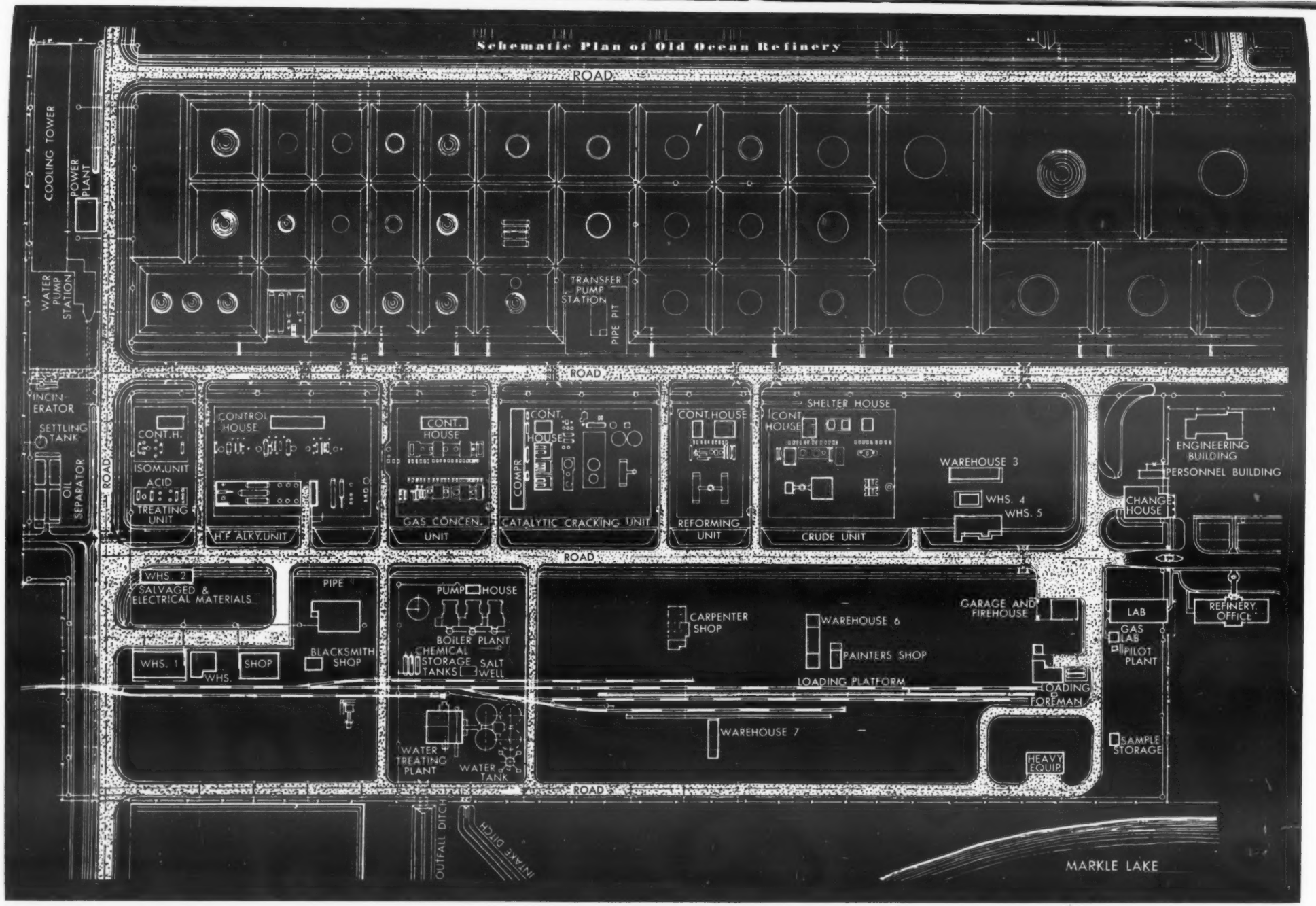


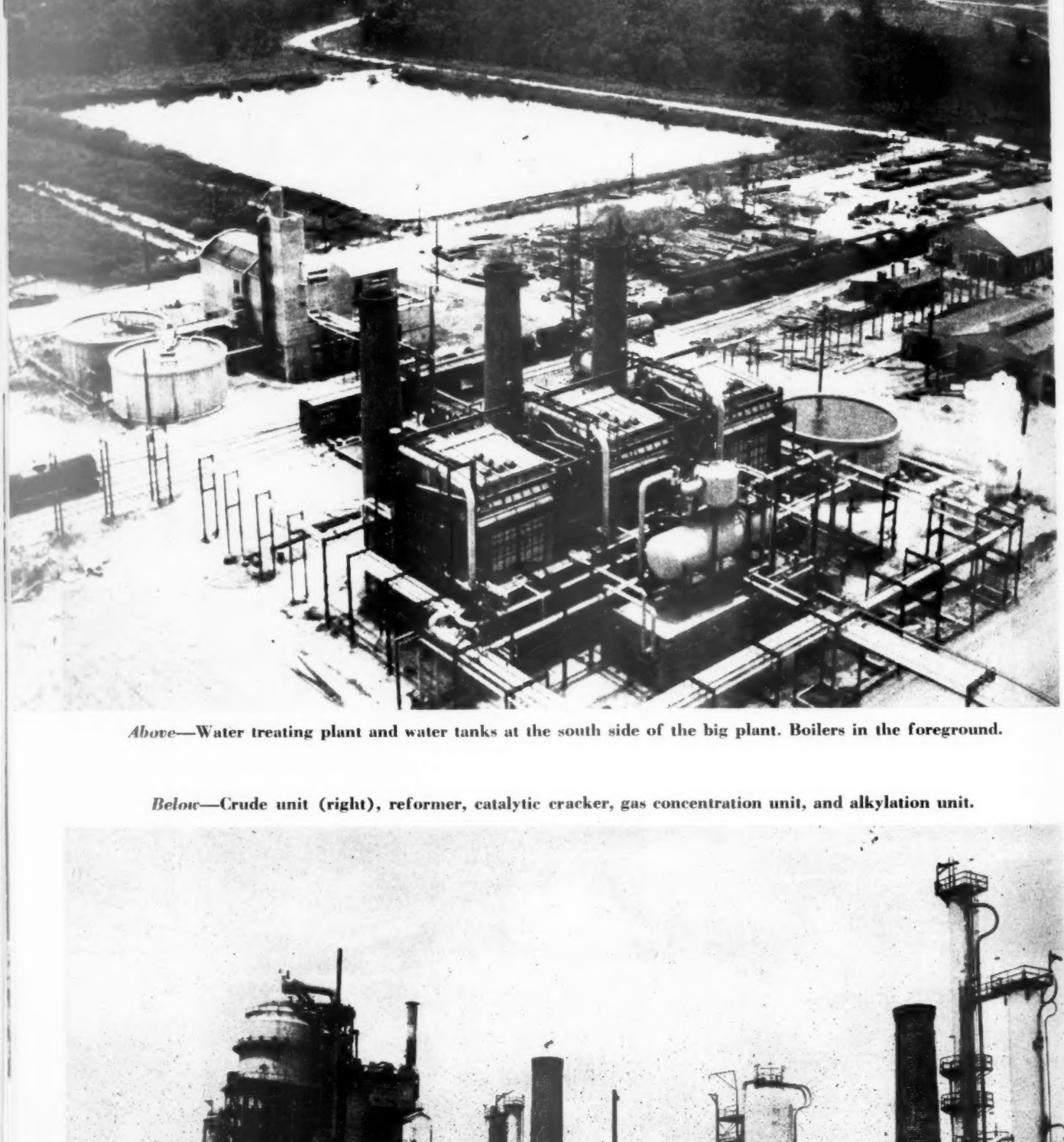
Thermal reforming unit above with updraft furnace in immediate foreground and deethanizer and absorber in the background. At left is the fractionation section of alkylation unit.

● **Fluid catalytic cracking unit.** Charge to the fluid catalytic cracking unit is 12,000 bbl. a day of combined light and heavy gas oils from the crude oil unit, as well as lean oil produced by the reforming unit when it is necessary to undercut reformer stabilized gasoline.

The gas oil is charged to the first-stage reactor after having first been preheated in heat exchangers and in the preheater furnace. The reacted vapors from the first-stage reactor pass out overhead to the bottom of the first-stage fractionating column, which is 15 ft. in diam. by 89 ft. high. A 400°F. end point material is carried overhead and light and heavy gas oils are drawn off the recycle sidecut stripper. The bottoms, which contain any residual catalyst, are returned to the reactor after being passed through steam generating equipment. The 400°F. end point material is carried by pump and compressors to the fractionating section of the gas concentration unit where pentanes and lighter are first removed in an 8-ft. 6-in. by 83-ft. depentanizer column and taken to the alkylation feed preparation section. Bottoms from the first-stage depentanizer column then go to a rerun column, where it is split into hexanes to 340°F. end point, and this is carried overhead to the gasoline splitter, which column is 8 ft. in diam. by 35 ft. high. Bottoms from the rerun column, which is 10 ft. diam. by 50 ft. high, go to intermediate storage as part of the charge for the second-stage reactor of the catalytic cracking unit. Material going to the gasoline splitter from the rerun column is split into hexanes of 250°F. end point, which go overhead to intermediate storage along with the rerun column bottoms for charging to the second-stage reactor, and an aromatic fraction that comes off the bottom. The latter boils between 250 and 340°F. After a light sulphuric acid treat it is ready for blending into Grade 130 aviation gasoline.

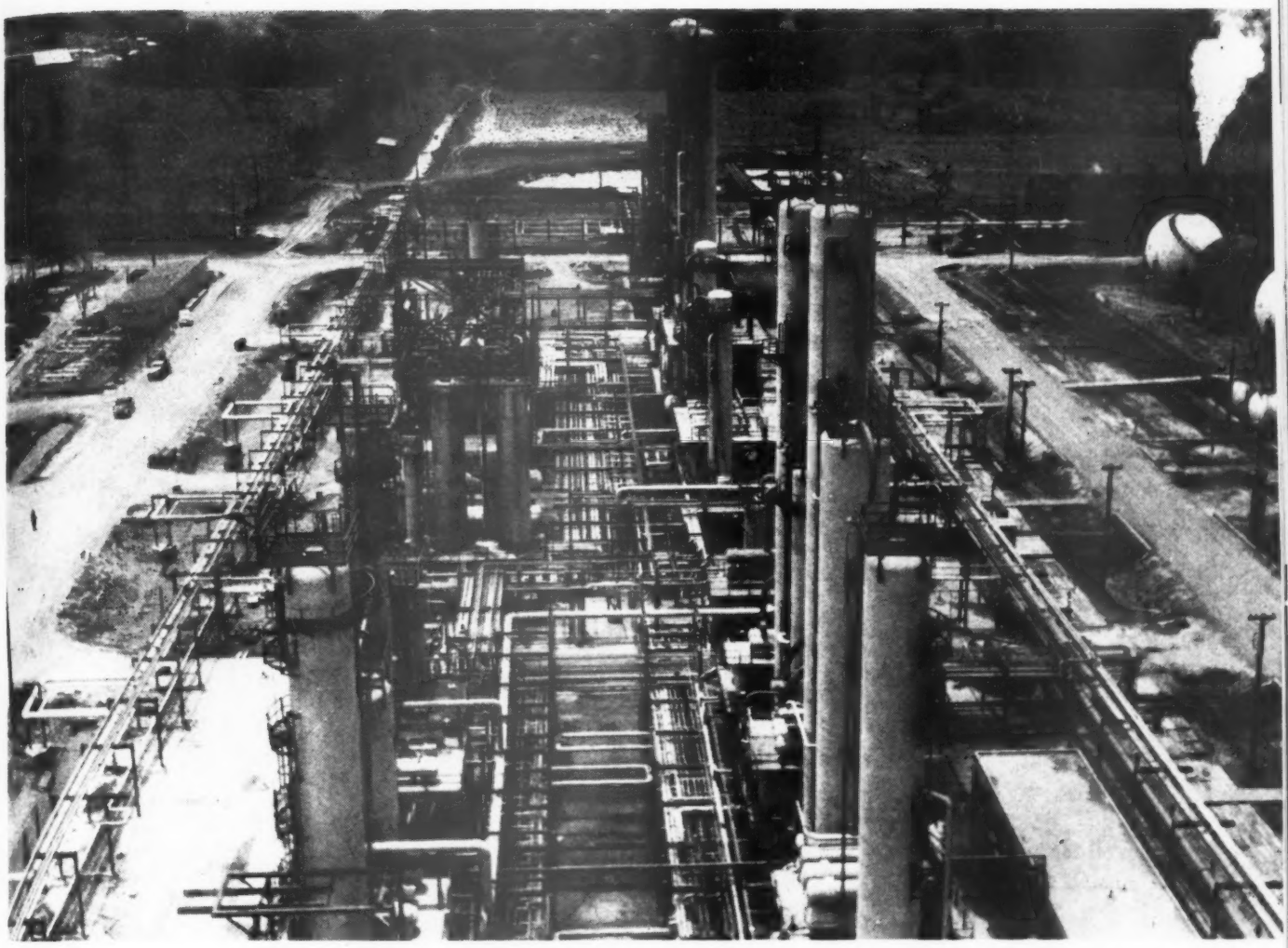
The second-stage catalytic cracking unit charges a first pass naphtha consisting of C_6 to 250°F. initial and 340-400°F. end point material. This material is catalytically retreated at approximately 960°F. reactor temperature. The reacted materials pass overhead from the reactor into the second-stage fractionator, which is 10 ft. 6 in. in diam. and 89 ft. high. A 400°F. end point cut is taken overhead and a heavy gas oil is taken from a side-cut stripper that operates in conjunction with the fractionating column. Column bottoms, containing catalyst carried over from the reactor, are pumped back into the reactor along with the fresh naphtha feed. The 400°F. end point material is depentanized in the second-stage depentanizer column, which is 6 ft. 6 in. in diam. by 89 ft. high. The C_5s and lighter are discharged to the alkylation feed preparation section. The depentanized bottoms are transferred to the second-stage rerun column, which is 7 ft. in diam. by 50 ft. high. A 350°F. end point material is taken overhead from this column. This is catalytically retreated base stock that has a Reid vapor pressure of approxi-


Schematic Plan of Old Ocean Refinery
ROAD
COOLING TOWER
POWER PLANT
WATER PUMP STATION
TRANSFER PUMP STATION
PIPE PIT
INCIN-ERATOR
SETTLING TANK
OIL SEPARATOR
CONT.H.
ISOM.UNIT
ACID TREATING UNIT
CONTROL HOUSE
H.F. ALKY.UNIT
CONT. HOUSE
GAS CONCEN. UNIT
COMPR
CATALYTIC CRACKING UNIT
REFORMING UNIT
SHELTER HOUSE
CRUDE UNIT
WAREHOUSE 3
WHS. 4
WHS. 5
ENGINEERING BUILDING
PERSONNEL BUILDING
CHANGE HOUSE
WHS. 2
SALVAGED & ELECTRICAL MATERIALS
PIPE
BLACKSMITH SHOP
WHS. 1
WHS.
SHOP
PUMP HOUSE
BOILER PLANT
CHEMICAL STORAGE TANKS
SALT WELL
CARPENTER SHOP
WAREHOUSE 6
PAINTERS SHOP
LOADING PLATFORM
GARAGE AND FIREHOUSE
LOADING FOREMAN
LAB
GAS LAB
PILOT PLANT
REFINERY OFFICE
WAREHOUSE 7
HEAVY EQUIP.
SAMPLE STORAGE
WATER TREATING PLANT
WATER TANK
OUTFALL DITCH
INTAKE DITCH
MARKLE LAKE



Above—**Water treating plant and water tanks at the south side of the big plant. Boilers in the foreground.**

Below—**Crude unit (right), reformer, catalytic cracker, gas concentration unit, and alkylation unit.**



Looking down central areaway of gas concentration and alkylation units.

mately 2 lb.. a 1-C octane rating of 93, and a 3-C rating of S-2.2.

Bottoms from the rerun columns are recycled to extinction.

All catalytically cracked oils from the FCC unit are blended into No. 2 furnace oil.

The FCC unit produces approximately 2400 bbl. of base stock a day, 3500 bbl. of B-B pentane-amylene, and 3500 bbl. of cracked gas oil.

● **Gas concentration unit.** The alkylation feed preparation section of the gas concentration unit receives 400°F. end point thermally cracked naphtha from the reforming unit, as well as the depentanizer overhead from both the first and second stage depentanizers of the FCC unit. This material is charged to a depropanizer where propane and lighter are taken overhead to the fuel system, bottoms going to a depentanizer column for recovery of butane-butylene and pentane-amylene fractions. The depropanizer is 8 ft. 6 in. diam. by 82 ft. high and the depentanizer 10 ft. 6 in. by 82 ft.

The butane-butylene, pentane - amylene fractions are discharged to the alkylation unit. The bottoms from the depentanizer column is stabilized reformed gasoline and this constitutes approximately 80 per cent of the plant's production of premium grade gasoline.

In the gas concentration unit there is also a 9-ft. 6-in. by 120-ft. isobutane column that separates isobutane from purchased butane and splits isomerization unit effluent.

The alkylate deisopentanizer, which is 8 ft. 6 in. in diam. by 112 ft. high, and the alkylate depentanizer, which is 6 ft. 6 in. by 70 ft., will be discussed in connection with the alkylation unit, although they are placed in the gas concentration area.

● **HF alkylation unit.** Alkylation unit charge is B-B pentane-amylene and isobutane. Produced is 4000 to 4500 bbl. of alkylate a day. The unit consists of 6 contactors, acid separating equipment, fractionating towers, and drying equipment.

The feed to the unit is caustic washed and dried before being charged to the contactors. Fresh olefin feed is mixed with recycle isobutane and recycle acid in the contactors. Effluent from the contactors flows into horizontal settlers for mechanical separation of the larger portion of the acid from the hydrocarbons. The hydrocarbons are then charged to an HF stripper column where all the acid is removed overhead, the acid being recycled to the contactor system.

The acid-free bottoms of the HF stripper are passed through bauxite towers to remove any trace of acid before being charged to the deisobutanizer columns.

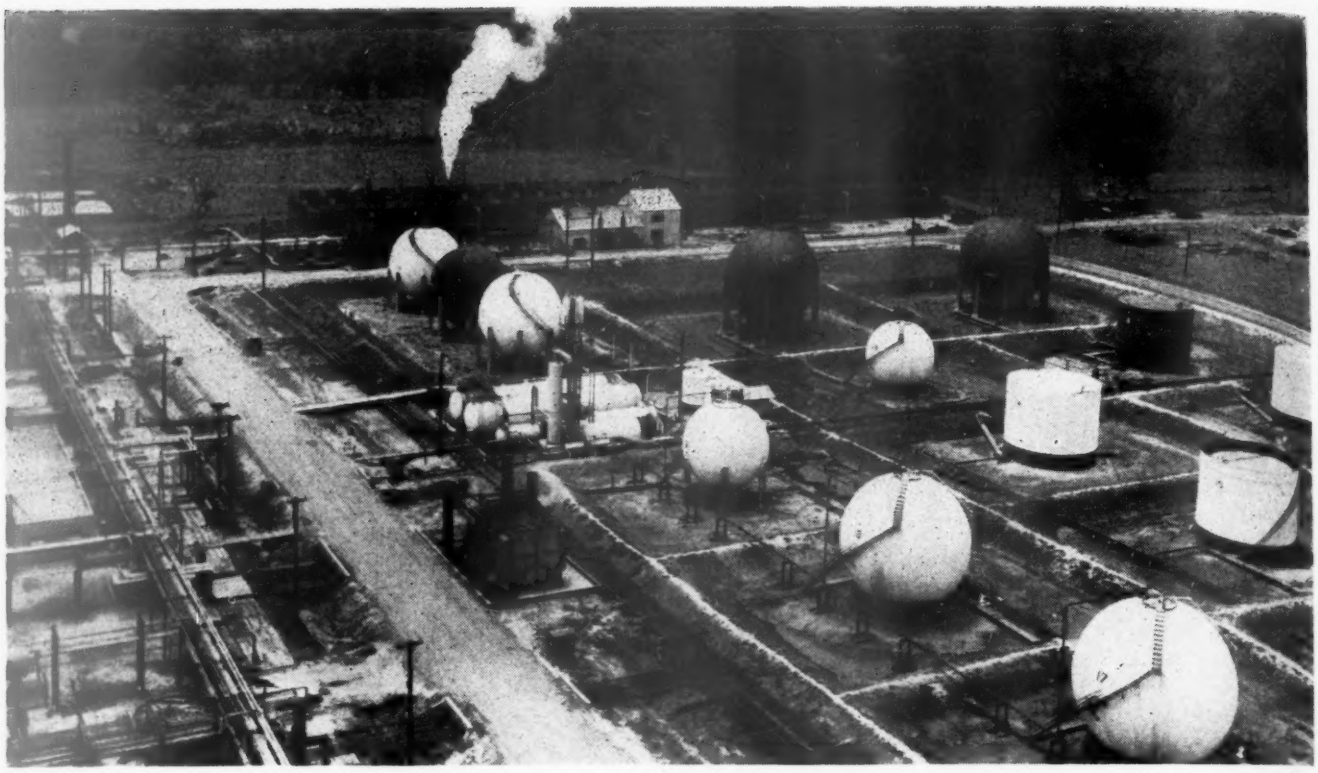
The HF stripper column is 8 ft. in diam. by 58 ft. high and the two deisobutanizer columns are 11 ft. by 126 ft.

Recycle isobutane is carried overhead from the deisobutanizer and pumped back through the contactors where it is mixed with fresh olefin feed. The bottoms from the deisobutanizer are charged to the debutanizer column, which is 7 ft. in diam. by 64 ft. high. The butane is taken overhead and charged to the field isobutane column of the gas concentration unit for further purification before being charged to the isomerization unit.

Bottoms from the debutanizer are pumped to the alkylate deisopentanizer in the gas concentration unit. The removed isopentane is pumped to storage where it becomes available for blending with aviation gasoline. The remaining material is charged to the depentanizer column. The normal pentane removed from the alkylate is charged to the stabilized reformed gasoline before going to the finished premium gasoline tanks.

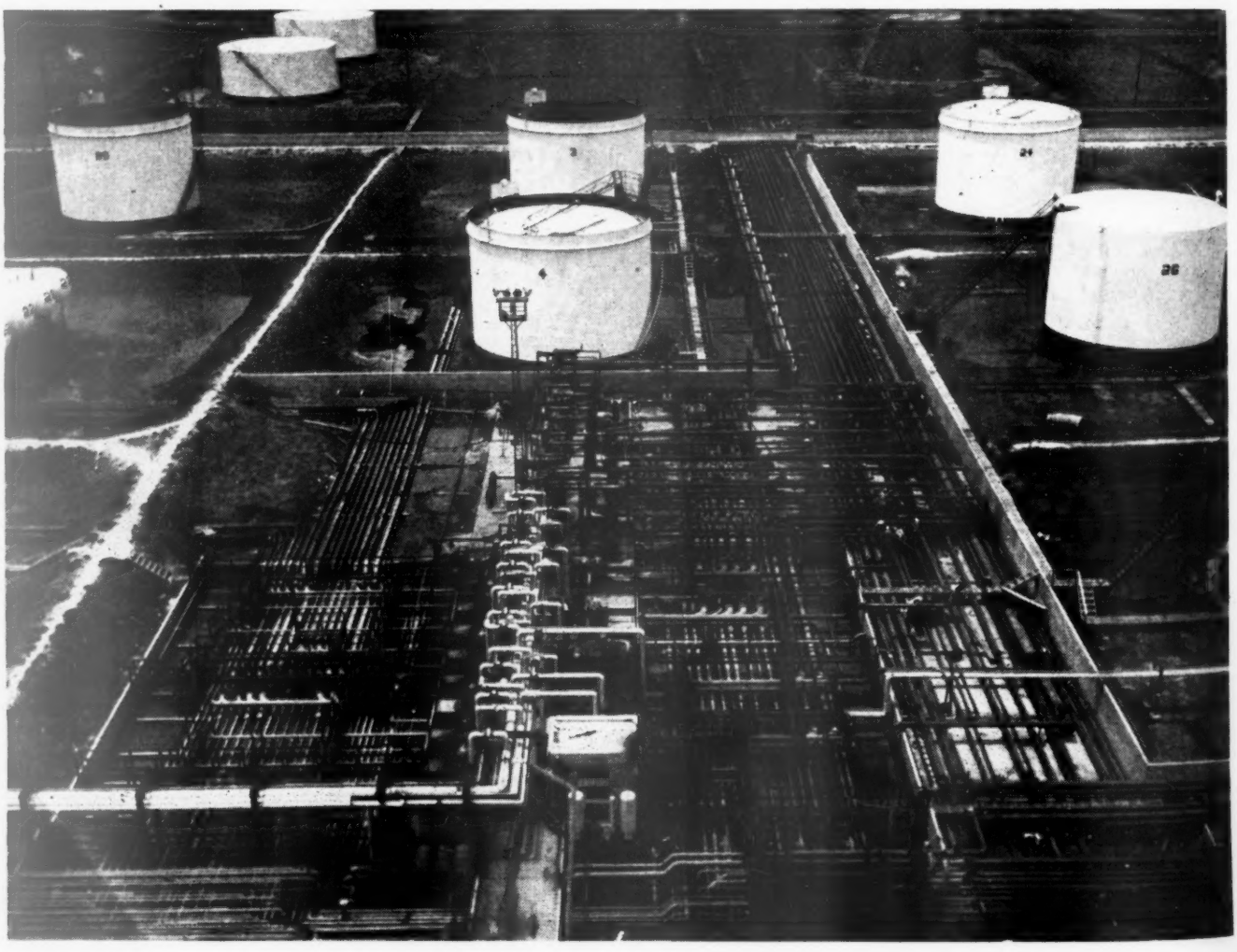
Depentanized alkylate is returned to the alkylation unit to the 7-ft. by 56-ft. alkylate rerun column, where heavy alkylate is removed from the bottom of the column and used as flush oil in pumps throughout the unit.

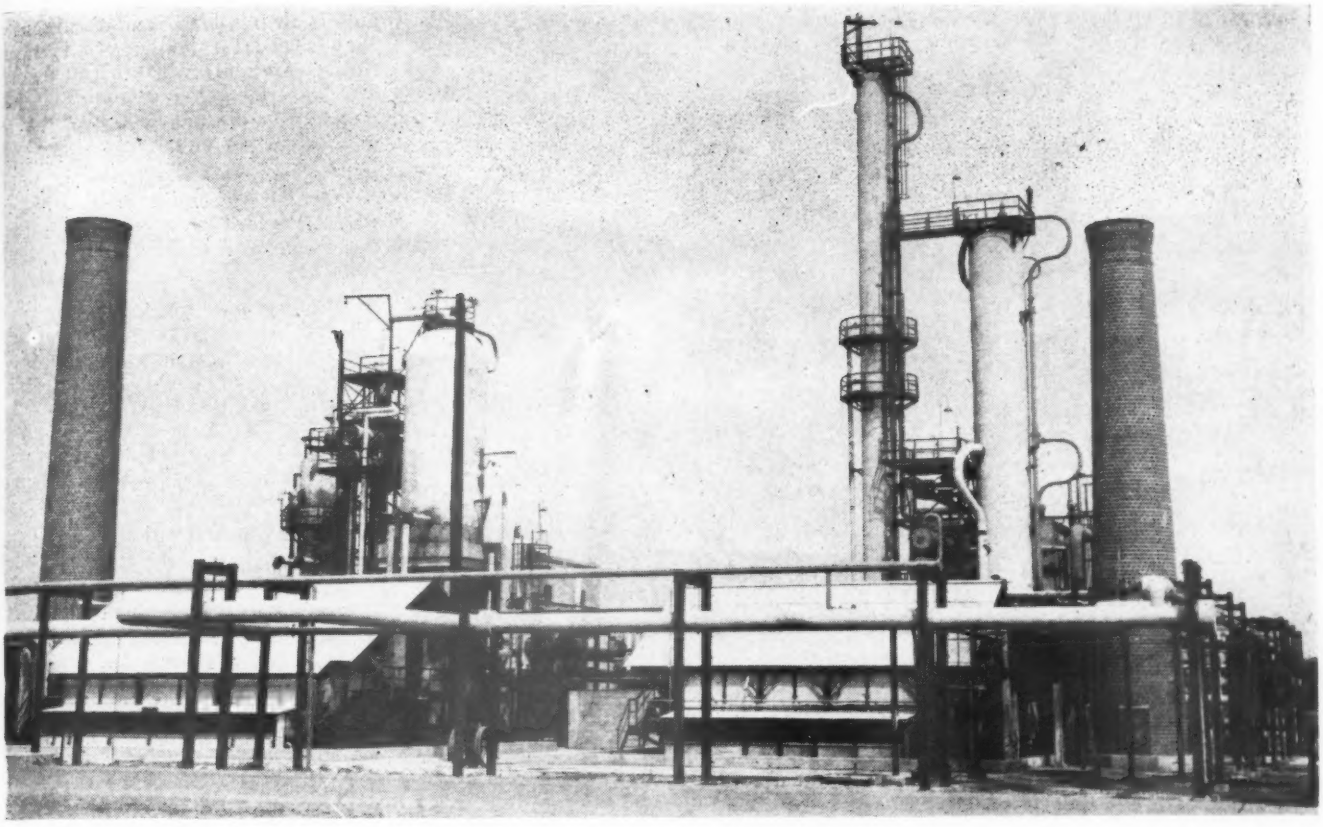
The acid regeneration section of the alkylation unit strips acids from tarry materials that are formed during the



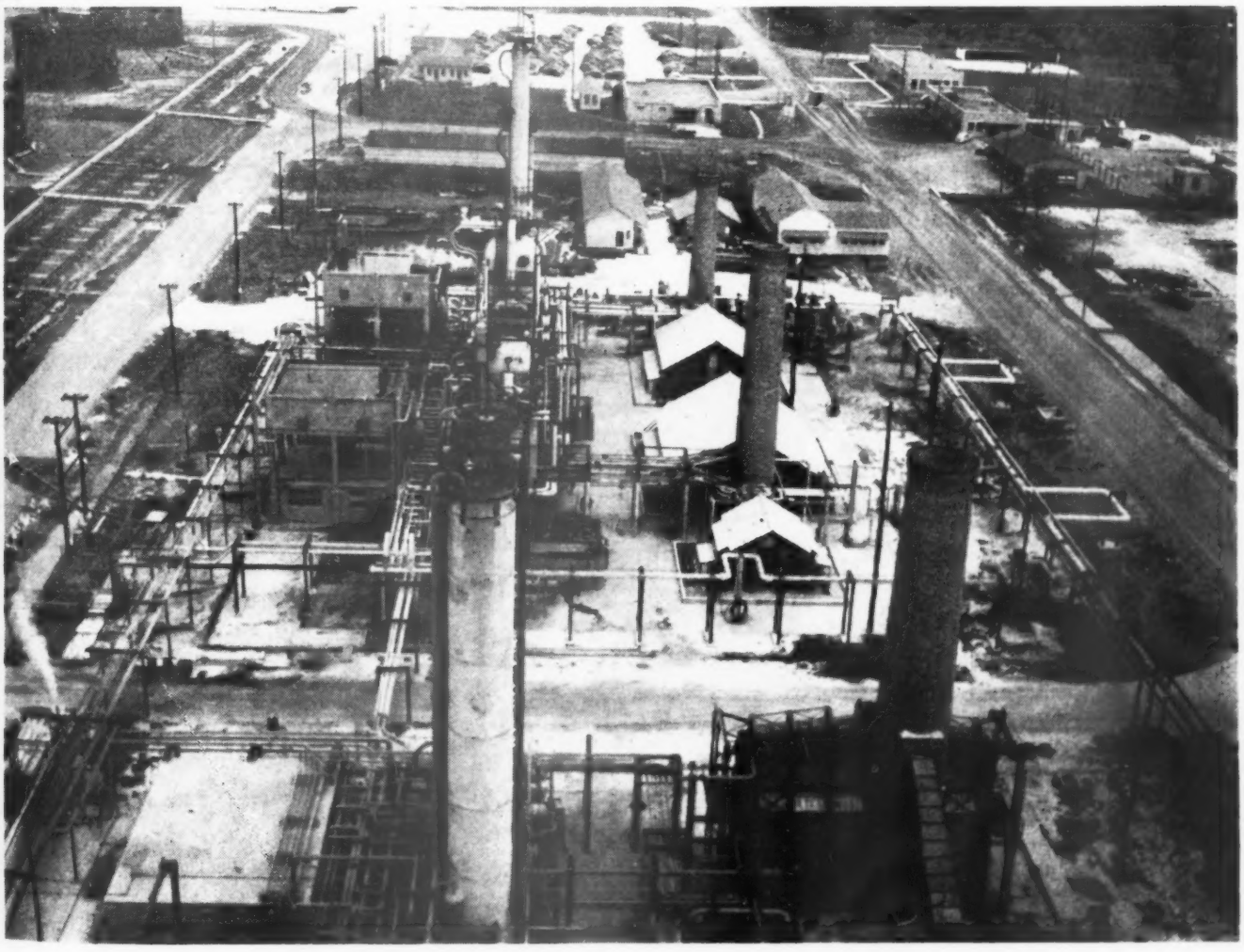
Tankage and acid blowdown section of alkylation unit (foreground). Cooling tower, electric power plant, water pumping station in background.

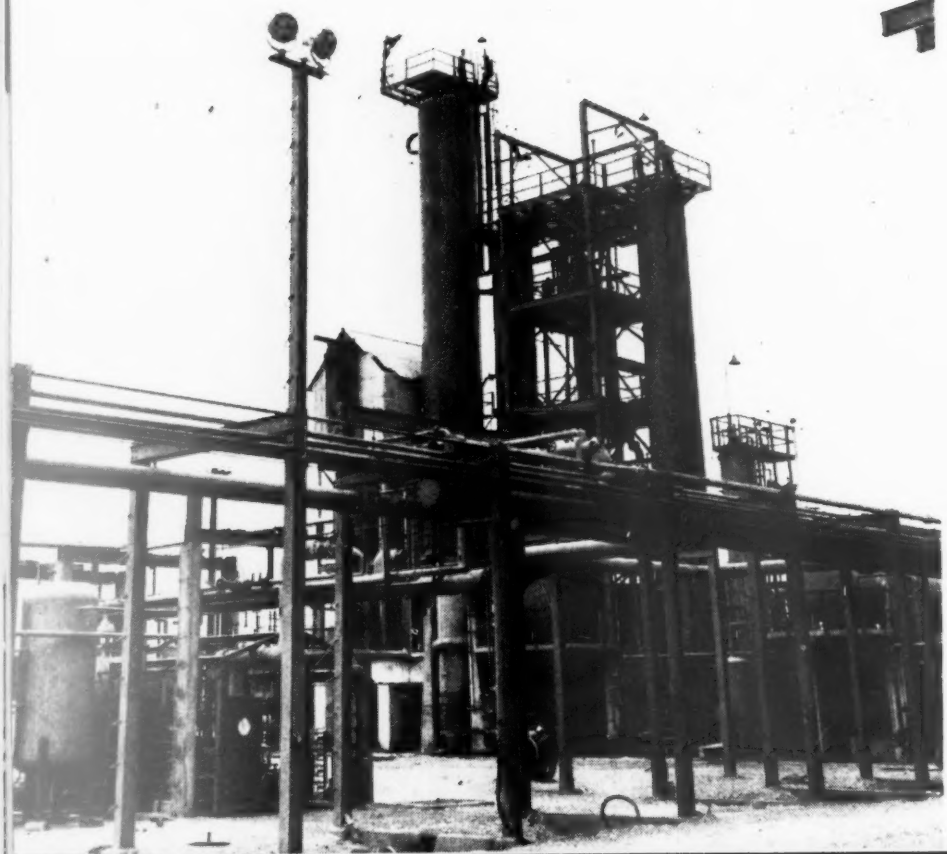
Transfer and storage pumping equipment across the road from the catalytic cracking unit.





Crude oil unit, two heaters, flash section showing flash tower, depentanizer and reboiler furnace.
Below, another view of the crude oil unit is in the background. Thermal reforming unit in foreground.





and is then filtered and recarbonated. Water used for boiler feed is treated through sodium hydrogen catexers at a rate of 3159 gal. per min. Effluent is blended for desired alkalinity at a rate of 630 gal. per min.

● **Cooling tower.** The refinery uses 60,000 gal. of cooling water a minute, which is cooled in an induced-draft type tower equipped with 54 fans. Cooling is from 120°F. to 90°F.

● **Power plant.** Electric power is provided by three generators. Two are of 750 kw. each, driven by 1090-hp. V-type 10-cylinder gas engines. The other is a 300-kw. generator that is driven by a 750-hp. steam turbine. At the present time a 1500-kw. steam-turbine-driven generator is being installed to supply additional power.

● **Boiler plant.** The boiler installation consists of three water-tube type units that produce 450-lb. steam at 100° superheat. A total of 750,000 lb. of steam per hour is provided.

● **General.** J. F. Pritchard and Company was the general contractor for construction of the refinery, and the crude oil unit is that company's design. The thermal reforming, FCC, alkylation, and isomerization units are Universal Oil Products Company design. ★★★

process. The regenerated acid is carried overhead on the regenerator column and the tarry material is burned in an incinerator. The regenerated acid is then recycled to the contactors.

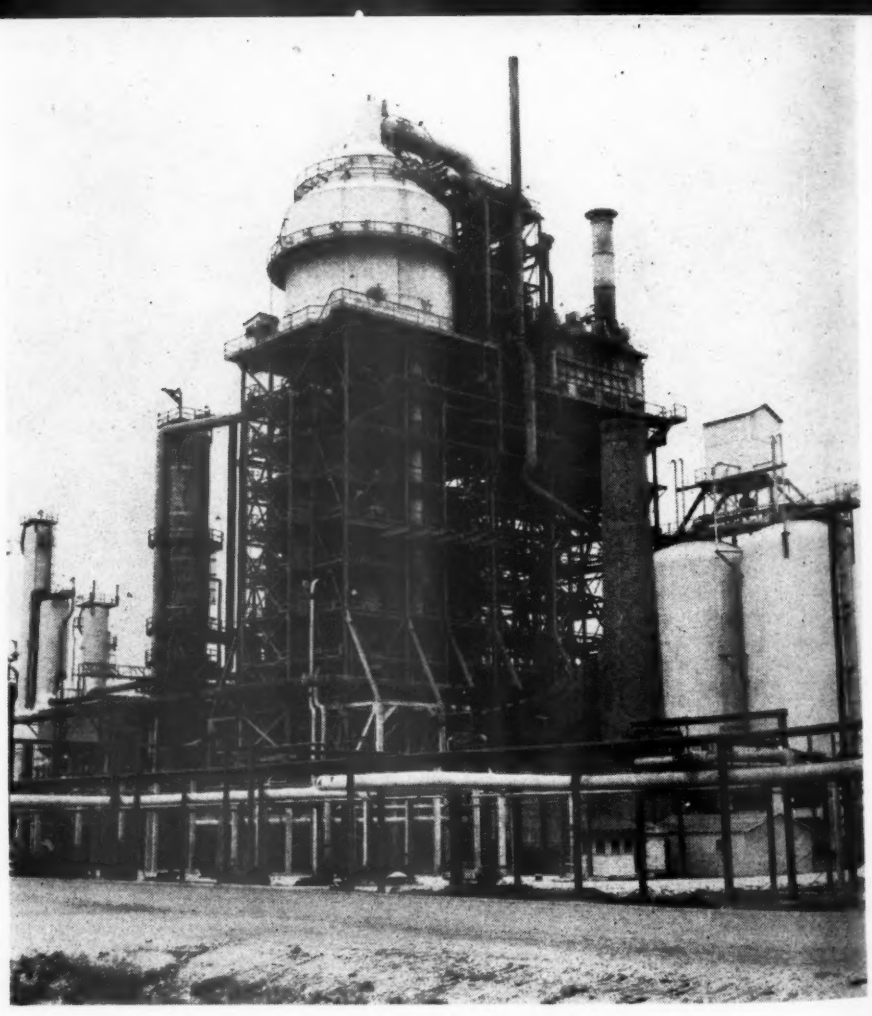
● **Isomerization unit.** Normal butane is charged to the isomerization unit and approximately 2000 bbl. of isobutane produced a day.

Normal butane feed is charged through a feed drier, thence into an aluminum chloride saturator before going to the reactor. In the reactor it is mixed with hydrochloric acid and the effluent is drawn off to an aluminum chloride tower. Reacted and unreacted butanes are carried overhead from the aluminum chloride column and then charged to the hydrochloric acid fractionating column where hydrochloric acid is removed overhead and the butanes removed as the bottom product.

The butanes are caustic scrubbed to remove any traces of residual acid before going to the field isobutane column for separation of isobutane from normal butane.

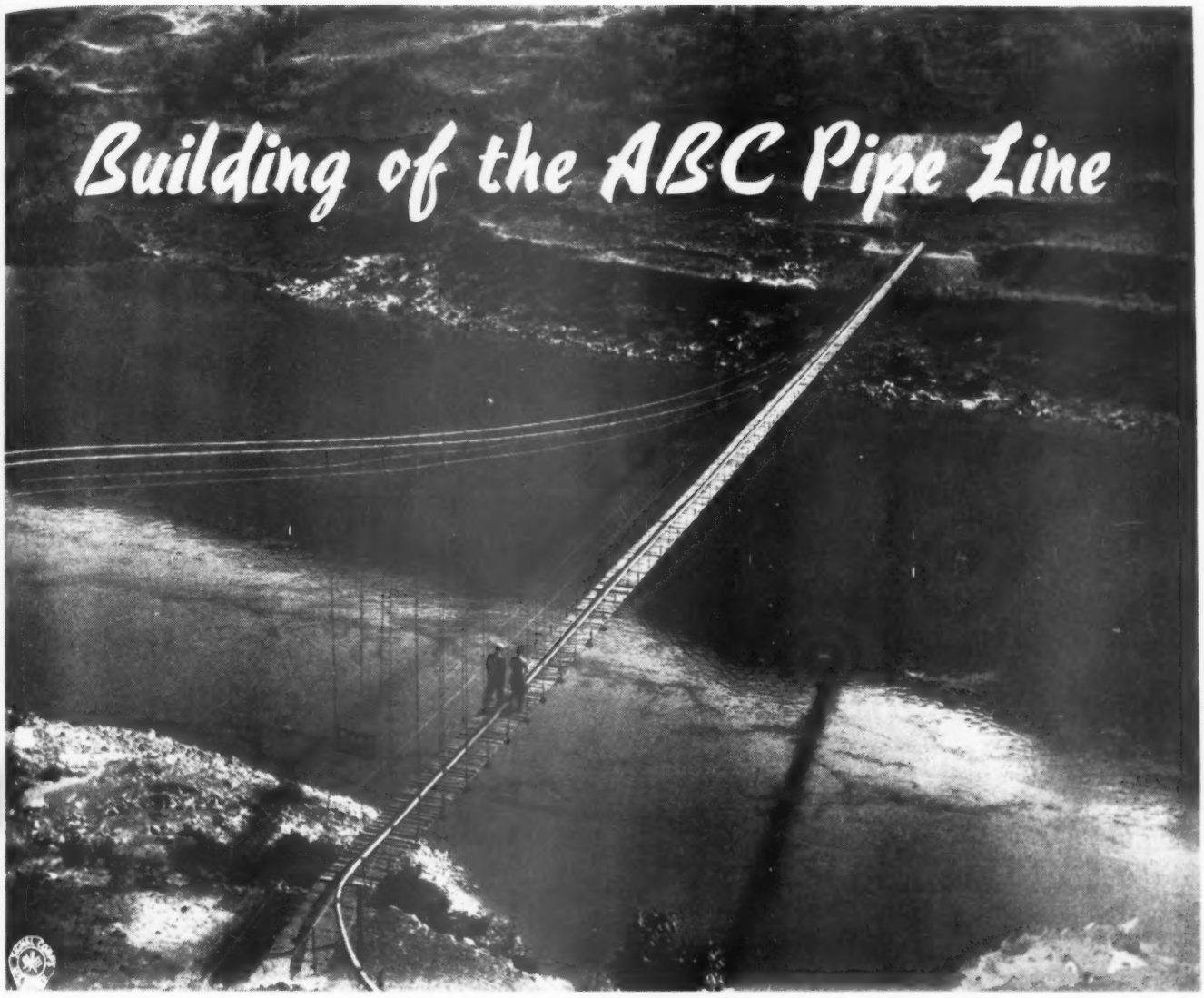
The aluminum chloride drawn off the bottom of the aluminum chloride column is recycled to the reactor, and the hydrochloric acid removed overhead from the hydrochloric acid fractionating column likewise is recycled to the reactor.

● **Auxiliaries. Water treating plant.** The water treating plant has a design capacity of 4000 gal. per min., which is approximately large enough to supply a city of 25,000 persons. The water is treated initially with lime and coagulent,



P 615.92

Building of the ABC Pipe Line



Small pipe line suspension bridge.

In October, 1943, American and Chinese soldiers were slowly pushing the Japanese back through North Burma to remove the threat of a Jap-Axis link-up across Asia, which would have proved disastrous to the Allies.

American engineers were carving the Ledo road through the impossible terrain in support of the fighters but even the road builder needed help. Huge quantities of fuel were needed for the bulldozers, trucks, and heavy equipment engaged in road construction, and by the time the point of the road was at the 50-mile mark, 40 per cent of all transportation over it was trucks supplying this fuel.

The solution to the supply problem was obvious to Col. Lewis A. Pick. The pipe line to China, already authorized by the Quebec Conference, had to be started to supply troops and road builders in the forward areas. He gave the orders to begin the ABC pipe line, Assam-Burma-China section of the world's longest military pipe line.

Only a handful of specially trained pipe line engineers were available to supervise the work of a colored engineer construction company assigned to start the line.

These untrained men made up by hard work what they lacked in knowledge, and soon had pushed the line from the small refinery at Digboi, Assam, to the 25-mile mark on the road. There they were joined by combat engineers in the task, and when additional pipe line engineers arrived to take over construction in February, 1944, gasoline was being dispensed directly from the pipe line within a few miles of the fighting front.

Unfortuately, the trained pipe line engineers arrived along the road far in advance of their regular equipment. Their welding machines, trucks, and other heavy units were somewhere en route to them along the world's longest supply line from the States. Undaunted, the engineers borrowed what equipment they could from units working on the road.

The 1800-mile pipe line to China was a major engineering achievement and vital to winning of the war.

Transportation continued to be the biggest problem for everyone working along the road. Trucks depreciated rapidly in the heavy hauling they were subjected to over the mountainous roads. A set of brakes could be expected to last one month, and brake bands were almost unobtainable.

The vital urgency of the job was felt by all who worked night and day to speed the project. On May 13, 1944, the first aviation gasoline arrived at the strategic airbase of Shingbwiyang, but engineers did not pause. Another airstrip was under construction a few miles up the road at Tingkawk Sakan, and the pipe line had to reach there for the opening of the field.

The long heralded monsoon struck in full fury in May and it could not have arrived at a more undesirable time. Be-

tween Shingbwiyang and Tingkawk Sakan road engineers were going about the seemingly impossible job of bridging the 13-mile swamp, which the monsoon had converted into an inland sea. A one-way causeway was in operation, but traffic was so heavy that pipe line engineers could not monopolize its use to get their line built.

They were, however, given a high priority. Working mostly at night they took pipe from trucks moving at snail speed along the bridge and walked it into position through waist-deep mud and water. The pipe was coupled from boats and allowed to sink into the morass. When the water receded in December, it was found that the pipe line was all on dry ground, and that the job could have been done under normal conditions in a fraction of the time it actually took.

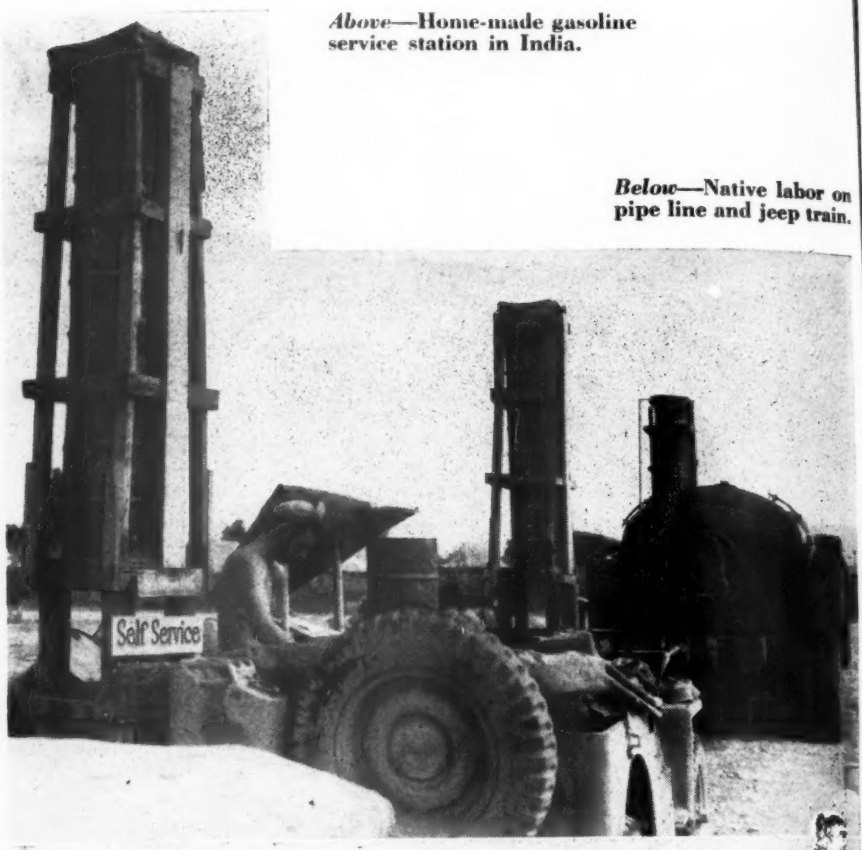
Need of the combat troops and road builders took priority on the first shipments of fuel through the line to Tingkawk. Gasoline and diesel oil arrived there on June 10, relieving approximately 40 per cent of the truck shipments, which previously had had to battle the causeway bottleneck. By June 17, 100-octane gasoline was being dispensed to fighter planes, combat cargo planes and bombers at every airstrip then in the combat zone.

When the pipe line from Calcutta was completed to join with the ABC pipe line, 100-octane gasoline, which had been flown from the Calcutta terminals, was pumped all of the way through the military pipe line.

Near Warazup, the pipe line and the Ledo Road entered the Mogaung Valley, where jungle vegetation is reputedly the heaviest in all of North Burma. The rains continued, and for one 45-day period, pipe line engineers in the area worked 12 hours a day without dry clothing. Few had even a dry bed to sleep in. Keeping personal equipment usable was one of the biggest problems at this time. A pair of heavy duty army shoes had a life expectancy of ten days in the mud and water. Jungle boots came apart in less than week. Clothing mildewed in water-proofed bags. Finally despairing of keeping dry, the men worked in the rain without being hampered by boots or raincoats.

The insistence of the monsoon and the jungle insects began to take a heavy toll on the health of the men. Malaria, dysentery, and typhus incapacitated a large number of the workers, but still the work went on. Suppressive atabrine treatment and rigid malaria control became compulsory, and with its administration the malaria rate declined until it became negligible. Vitamin deficiencies caused by lack of sunshine and the Spartan diet imposed by absence of fresh meats and vegetables were partially remedied by the issue of a daily ration of vitamin tablets.

Leeches became one of the biggest nuisances to plague the workers. When a man stopped for a moment in the jungle the little creatures literally swarmed over him. One of the standing jokes at this time was that blood plasma was to be pumped through the pipe line to enable medics to replace the blood taken by the blood sucking worms.



Above—Home-made gasoline service station in India.

Below—Native labor on pipe line and jeep train.

Stories about snakes and wild animals were legion, but there is no record of a pipe line engineer being harmed by either. Hunting offered about the only diversion for the men, and many tigers and pythons were killed. Deer abound in North Burma, and parties were regularly sent out to obtain fresh venison for the mess halls.

Indian Pioneer troops had been assigned to work with pipe line engineers, and their knowledge of the jungles made them invaluable to the Americans. They were primarily used to prepare the pipe line trace, but their ability to catch on to the intricate work soon made it pos-

sible for them to be used to supplement the skilled workers actually engaged in construction.

Fighting for the strategic railhead and supply city of Myitkyina was officially ended on August 3, 1944. Within nine days a complete petroleum distributing company had been flown into the battered airstrip, and had received 20 miles of pipe by air.

The taking of the city by the legendary Merrill's Marauders with the assistance of combat engineers and American-trained Chinese soldiers made possible the final phase of the North Burma campaign. To take full advantage of the situation, air bases had to be expanded even before the road was completed there. Huge quantities of diesel fuel and aviation gasoline were needed immediately, and construction of a temporary pipe line offered the best remedy for the situation.

The Stilwell road was to be cut through virgin country from Warazup direct to Myitkyina, but at this time it had not been started. Pipe line engineers began working toward one another from Warazup and Myitkyina, building their temporary line through Kamaing and Mogaung.

Only a combat trail existed between Warazup and Kamaing, and it was impassable. Water was 4 to 5 ft. deep along parts of the proposed right-of-way. Tractors pulling pipe sleds bogged down, and only pontons and assault boats were able to get the supplies into position. Some elephants were used, but they proved unsatisfactory because of the long trips and the inability of the native handlers to understand the urgency of the work.

Pumps and pipe were sent by ponton rafts to Kamaing, where two American and some reclaimed Japanese trucks were available for use. In some places, pipe was coupled into 600-ft. sections on dry ground and floated into place. It was necessary to put a 700-ft. welded section of pipe over the Mogaung river at its highest flood stage. When the river receded it was found that 70 ft. of pipe would have been sufficient under normal conditions.

Diesel fuel arrived at Myitkyina days ahead of schedule and soon 100-octane gasoline was flowing into storage tanks at a sufficient rate to support the ever mounting campaign.

While the temporary line was being built, other pipe line engineers, working with the road builders were putting in the permanent lines along the shorter new road.

Never was there a pause in construction activities. Even before the road was finished to Myitkyina, pipe line engineers, getting their supplies by air, were pushing on toward the besieged city of Bhamo. One detachment was unloading pipe from combat cargo planes on the first day the newly captured airport at Bhamo was in operation. Three days after the fall of this Japanese stronghold, gasoline was being dispensed to trucks, and pipe line engineers had by-passed the town to continue pipe line construction toward China.

The success of the Northern Combat Area Command in clearing North Burma of Japanese to open the land route to China was assured, but far from a reality in October, 1944, when it was decided to start the pipe line back toward Burma from the China side. Simultaneous work on the pipe line from both directions was a necessity because the pipe line engineers could not by-pass the men doing the actual fighting.

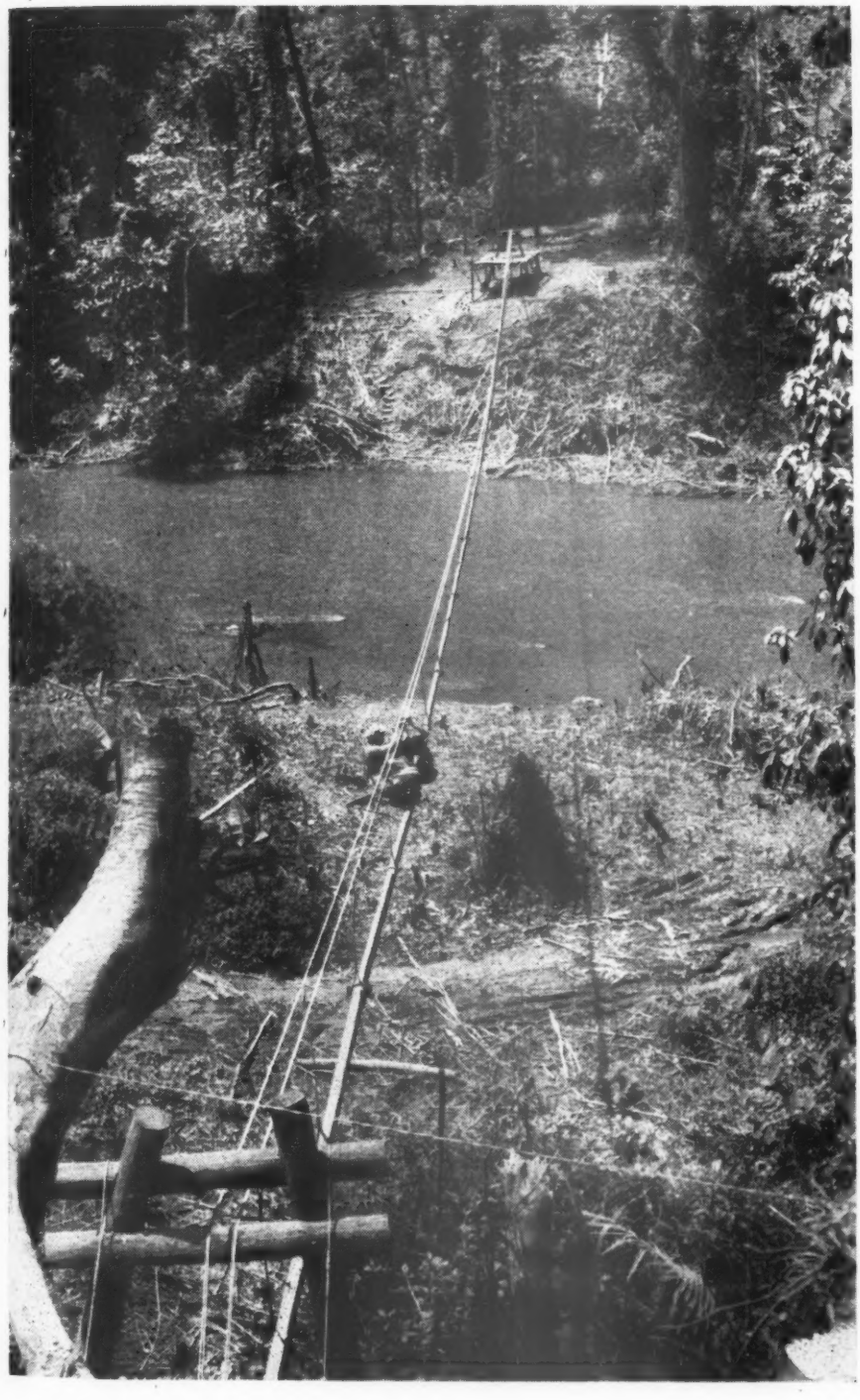
A small group of pipe line engineers were flown over the Hump to establish an advance pipe line headquarters, and to prepare the way for large groups of trained pipe line personnel soon to follow.

While ground work was being laid in China, engineer petroleum distributing companies were at air bases in Assam, dismantling their equipment for air shipment. Soon personnel and supplies began to be flown out, and by mid-November, over-the-Hump shipment of personnel and equipment had exceeded 500 tons and was rapidly mounting.

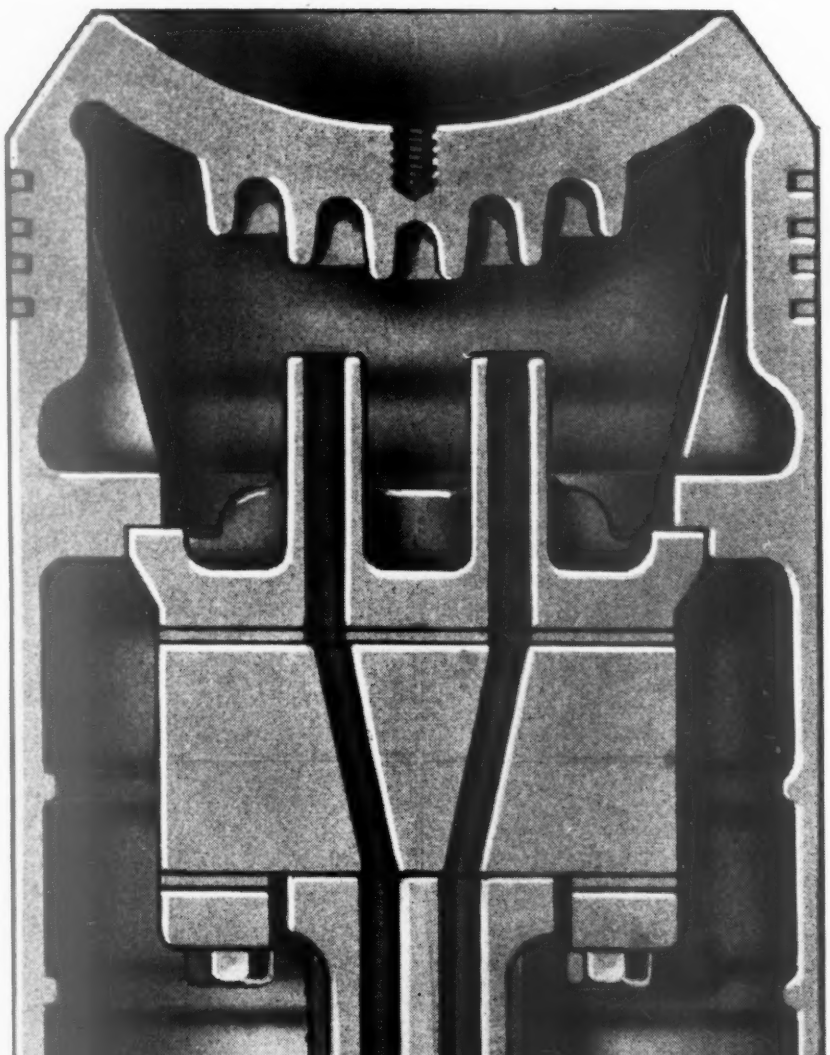
In early November, survey parties were sent along the Burma Road to determine the best route for the petroleum life line. At times their work was held up while Chinese expeditionary forces pushed the Japs back toward Burma.

(Continued on Page 64)

Pipe line walkers work on an overhead suspension.



Engineered for Prolonged Eff



EVEN HEAT DISSIPATION

This cutaway view of a GMV piston shows the uniformity which contributes to even heat dissipation without distortion or hot spots. Sections cut through the piston at other angles reveal the same uniformity.

UNEVEN HEAT DISSIPATION

A typical example of a non-symmetrical piston is shown below. Pistons of this character cannot be evenly cooled and are liable to localized hot spots.

TYPE GMV ANGLE Compressors

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Efficiency!...

UNIFORM CROSS-SECTION DESIGN OF GMV PISTON PERMITS CLOSE CLEARANCE, INSURES TROUBLE-FREE OPERATION—

Typical of the outstanding engineering which goes into every part of the Cooper-Bessemer GMV compressor is the piston shown on the opposite page.

1. The perfectly symmetrical piston crown means uniform heat dissipation, consequently uniform piston expansion without distortion.

2. GMV pistons are made of Meehanite, a close-grained high strength iron with unusual wear resistance.

3. Pistons are electroplated with bearing metal and rings are surface-treated to prevent scuffing and to provide initial lubrication when engine is started.

4. Cooling oil is supplied to pistons in a continuous flow through a chamber beneath each piston crown.

5. Four narrow, low-wear compression-type rings effectively seal the top of the piston and prevent blow-by.

Danger of ring-sticking, piston-sticking, hot spots or piston-scoring is reduced, and a minimum piston-to-cylinder clearance is possible.

The same skillful designing, the same experience with all phases of heavy-duty engine and compressor operation that have gone into this piston, are reflected in every other part of the GMV.

This skill, and the high standards that have characterized Cooper-Bessemer engines for over 111 years, are your guarantee of reliable GMV performance year after year.

This is the third in a series of advertisements on unusual engineering features of the GMV.

The GMV is more compact! ● It is a two-cycle engine. ● It comes to you already assembled — saving time and installation costs. ● It has much greater ease of moveability! ● The GMV has V-type cylinders! Saving floorspace. ● Its open-side, one-piece frame is unusually rigid — yet highly accessible. ● The GMV has interchangeable precision bearings throughout! ● Longer Life! ● Its connecting rods are articulated. Less bearing pressure. ● Plated Pistons! No scuffing — less running in! ● The GMV has oil-cooled pistons and narrow piston rings. Less Maintenance! ● Its crossheads are unusually large and husky! ● It has perfect cylinder scavenging. Higher thermal efficiency. ● Only the GMV has the famous Silent Scot injection system. Fuel economy! ● Auxiliaries are lay-shaft driven. No vibration! ● With it comes complete engineering service — automatic control — and a miracle of convertibility to gas or diesel! ● Four, six, eight or ten-cylinder, 400 to 1000 horsepower.

by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

...ston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles

Trucks loaded with pipe.

(Continued from Page 61)

When their work was finished, it was found that by their utter disregard for the mountainous terrain they had reduced the estimated length of the line in China by over 200 miles. This represents a saving of over 400 tons of supplies and seven months work for one pipe line company.

In some places the line scaled 9000-ft. mountains, or cut far off the Road. To get pipe, pump stations, and other equipment into seemingly impossible places, access roads were built, but even such roads were sometimes impassable for hard pressed motorized equipment.

Thousands of Chinese coolies worked with the pipe line engineers, dismantling equipment and moving it into position on their shoulders. In one area, pipe and supplies were carried over 11 miles in this manner.

Until two months after the opening of the Stilwell road, every piece of equipment used in the China project came over the Hump by air. Thousands of tons of personnel and equipment were moved into the new headquarters by Air Transport Command, Troop Carrier Command, and Combat Cargo planes.

While the first convoy over the Stilwell road was waiting at Namhkam on January 25, for the road to be cleared of Japanese between there and Wanting, pipe line engineers, too, were waiting to connect the final link of their line. When the first gasoline arrived at a major Chinese-American air base in China on April 9, 1945, six days had been cut from the target date set months before.

The completion of the approximately 1800-mile pipe line to China is a major military engineering achievement of this war. Without complete cooperation of the forces fighting the Japanese in Burma and China, the engineers building the Stilwell road . . . without the overall spirit of cooperation of all forces in the two theaters, the petroleum life line could never have become a reality.

Just as the building of the Stilwell Road was necessary before the Japs could be driven from North Burma to open the land supply route to China, so was the pipe line necessary before the road could be completed to do its job. For the part it played in supplying fuel for combat and road builders, the pipe line was well worth its cost in lives, effort, and money. ★★★

P 615.

PIPE LINES AIDED ARMY IN ITALY

CPL. DAVID L. MEYER
U. S. Army Correspondent

MEN and rifles and tons of ammunition alone could not have achieved Allied victory in Europe. Right on the heels of fighting troops came the vital supplies like oil and gas and other pipe line products. These supplies and the men who build the pipe lines make advances possible. These oil men helped ready the final offensive that spelled the doom of Nazism.

Old fashioned Yankee ingenuity resulted in the laying of hundreds of miles of pipe under conditions not usually encountered in the States. The job had to be done, however, in order to supply the American 5th Army and the British 8th Army during the Italian campaign. In Italy, the duties of keeping the supply lines flowing to the two victorious Armies fell to the lot of the 703rd Engineer Petroleum Distributing Company, an important unit of Peninsular Base Section, the main Army Service Force in the Mediterranean theater.

Here are some of the things that had to be overcome:

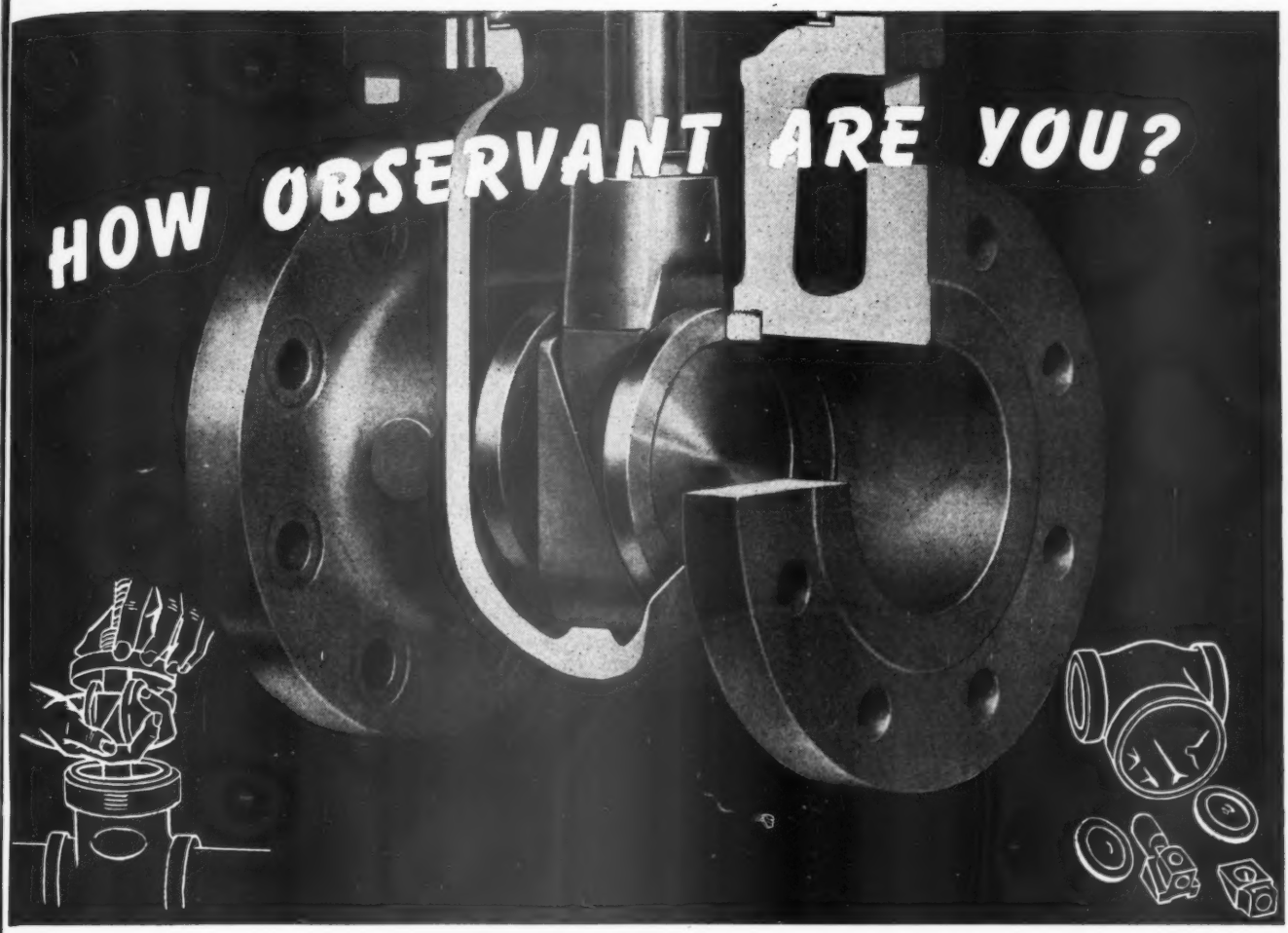
First, the mountainous terrain made operations difficult. "But they told us to lay those lines," said one of the men, "And we did."

Then speed was necessary. Speed in order to keep the enemy on the run. Speed in order to save American lives. It was necessary, therefore, to build the pipe lines on the surface to save time in digging. Main roads and trails could not be used because the troops and other supplies, too, could not be hindered. Thus new trails had to be cleared by bulldozers and new trails meant more mines to be cleared. PBS engineers and officers and enlisted men of the 703rd finally accomplished this difficult and dangerous task.

Speed, too, meant repairing all available equipment. Italian storage tanks left behind by the retreating Nazi were rebuilt and additional portable tanks were constructed. Fuel dispensing racks were built and rail tank cars had to be loaded and then unloaded at the docks. At all times, breaks and leaks had to be repaired immediately.

In one six-month period more than 2,150,000 bbl. of pipe line products were pumped to the front lines. This company pumps 80-octane and 100-octane gasoline plus diesel oil and kerosine.

Last December the 703rd Engineers received orders to construct a 6-in. pipe line across the Arno River, with the river 60 ft. above its normal level and at its highest stage in 50 years. Sleet, rain, and mud interferred with the welding and pipe handling across a distance of 420 ft. A 1⅛-in. cable was first strung across the river and attached to two high tension derricks then not in use. The welding of the pipe was managed by lifting the pipe with block and tackle to a platform on a derrick about 30 ft. in the air and then welding it joint by joint. It took five days to complete the job and four days of tie-in and testing. Today the line is still in operation. The 703rd Engineers are justly proud of their record—and so are a lot of grateful fighting men. ★★★



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Quizzes and observation tests are so popular nowadays that we've worked out this one for you on the famous Darling Fully Revolving Double Disc Parallel Seat Valve.

Here's what to do—Study the above picture for one minute, concentrating on every detail. Then cover up the picture and ask yourself the 11 questions in the box at the right.

If you don't know the answers — when you look at the picture again — then you've a special invitation to get better acquainted with the Darling Fully Revolving Double Disc Parallel Seat Gate Valve. Just clip and send in the coupon below and get the answers.

TEST YOURSELF WITH THESE QUESTIONS?

1. *Is this a gate valve or a globe valve?*
2. *Is this valve open or closed?*
3. *How many parts make up the gate?*
4. *Are discs and wedges bolted together?*
5. *What is the function of the two discs?*
6. *What is the advantage in having discs fully revolving?*
7. *Are there two wedges? Why?*
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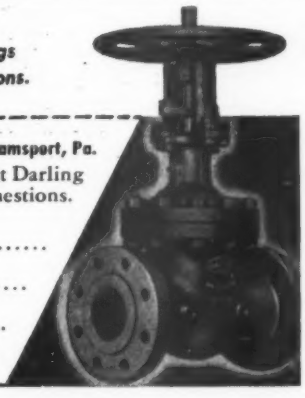
9. *Can parts be assembled incorrectly?*
10. *Where are pockets to collect sediment?*
11. *Service and long life considered, isn't this Darling Valve the best one you could buy?*

The coupon below brings the answer to the questions.



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SECONDARY RECOVERY IN CALIFORNIA

By **RICHARD SNEDDON,** *Pacific Coast Editor*

EXCLUSIVE

For the past year and a half there has been carried on in the Richfield District of Los Angeles a secondary recovery experiment that is being watched with decided interest by most of the operators in Southern California. This project was instigated by Union Oil Company after a thorough study and investigation of the Chapman zone in this particular field indicated that ultimate oil recovery would be low and that natural water encroachment was too localized to be of any importance in a recovery project. Coupled with these facts, the obvious trend of wells in many portions of the zone toward an unprofitable level of production was held to justify an effort to develop means of recovering some at least of the large quantity of oil remaining in the zone.

Early deliberations and investigation pointed to water flooding as the best means of accomplishing this, but since the literature held nothing that would be of help in establishing the method of procedure (reservoir conditions in the Chapman zone differ so widely from those encountered in other known flooding projects), the engineers who were responsible were not too optimistic of success.

Although laboratory tests were encouraging, there was no assurance that water would displace any appreciable quantity of oil from the Chapman sand under the existing reservoir conditions. It was, therefore, decided to launch a small scale project for two purposes; First, to find out whether or not oil in the sand could be displaced with water, and second, to develop any and all pertinent information that might be of value if it should be shown that water flooding on a larger scale might be later used as a profitable means of secondary recovery.

The Chapman zone at Richfield is found at a depth of from 3000 ft. to 3700 ft., and the productive portion is a large irregularly shaped oil sand, over 400 ft. thick at the top of the structure. Toward the edge of the field it is gradually replaced by intruding shale members, until at some points the interval becomes shale almost entirely. The sand is of medium grain and poorly sorted, with an average permeability to air of approximately 1100 millidarcys, an average porosity of about 31 per cent, and according to Pyle and Jones, the average interstitial water content is 37 per cent.

Oil from this zone ranges in gravity from 16 to 22 deg. API, and has a viscosity at reservoir temperature (140°F.) of 50 centipoises, that is, with no adjustment for gas in solution. It is estimated that the oil recovered up to the present time represents about 19 per cent of the total oil in the reservoir and that the ultimate recovery, without recourse to secondary methods, will be between 21 and 22 per cent of the oil in place.

Richard Sneddon

A number of considerations influenced the choice of location for the water flooding experiment. It was believed desirable to experiment with only a thin sand section, so that if failure occurred the attendant damage to the reservoir would be minimized. It seemed reasonable to select a location that had not suffered water encroachment. It was reasonable, also, to choose an area in which the wells were approaching a level of unprofitable production. Finally, the project should be located so as to minimize offset difficulties. With these matters agreed upon, a site was chosen in the southwestern portion of the field, not far from the pinch-out of the Chapman sand. At this point the sand body is about 50 ft. thick, and the two producing wells nearest the injection site were yielding 8 bbl. of fluid a day of which 7 were oil and 1 water.

An underlying zone (Kraemer) was believed productive at this location, and so the input well was drilled to the deeper zone for completion as a producer after the water flooding project had been finished. All the Chapman sand in the input well was cored and subjected to detailed analysis. The sand body was found to show 38 ft. of penetration, and the average permeability and porosity were lower than the averages for the entire zone, permeability to air being 422 millidarcys, and porosity 29.1 per cent. The well was completed by running a 5½-in. combination string to bottom, cementing through perforations at the base of the Kraemer shale and gun perforating the Chapman sand. The Kraemer zone was fully protected by: (1) Leaving in the plug and retainer used in the cementing operation, and (2) setting a bridge plug below the Chapman sand.

When pumping equipment had been installed and the well placed on production, it averaged 7 bbl. a day, with a 20 per cent cut and a gravity of 18.2 deg. API, for a period of three weeks. Then, after thoroughly cleaning the sand face, and establishing the fact that the well had reached the point of normal steady production, (this took several more weeks of producing), the rods and tubing were pulled and 2½-in. cement-lined tubing was run with a packer set a few feet above the perforations.

Waste water from the Richfield field itself seemed to be the logical supply for injection purposes, and since preliminary tests showed that core samples from the Chapman zone were plugged by this water when untreated, and even when filtered, some effective form of treatment was obviously necessary. The water was found to contain a considerable amount of floccuable material, thorough oxidation of which had to be contrived to prevent plugging of the core samples, and hence eventual plugging of the formation from which the cores were taken.

A small pilot plant was erected to develop an adequate treating process for the waste water, and the following steps were finally decided upon:

1. Primary flocculation with alum to remove bulk of suspended matter.
2. Oxidation of soluble organic material to a form that can be flocculated.
3. Secondary flocculation with alum.
4. Filtration.

At this point in the proceedings a plant was built to treat 1000 bbl. of water a day, using the process outlined. In designing the plant, advantage was taken of the topography to provide gravity flow and as far as possible make the treatment automatic. The operation is roughly as follows: Water from the central gathering system, after skimming is pumped into the first flocculator. As it enters it is mixed with alum, and flocculation takes place as it rises through an

(Continued on Page 70)

Experimental project demonstrates that water-flooding is an effective medium of recovery for Chapman zone of Richfield District.

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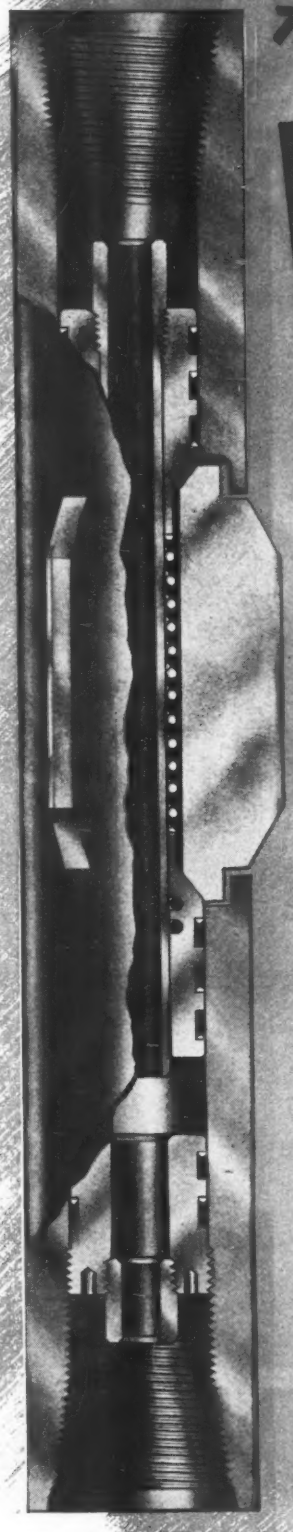

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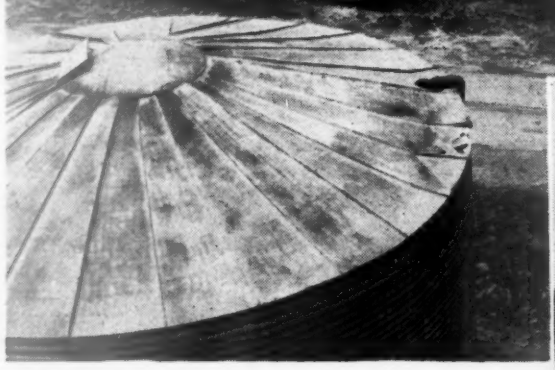

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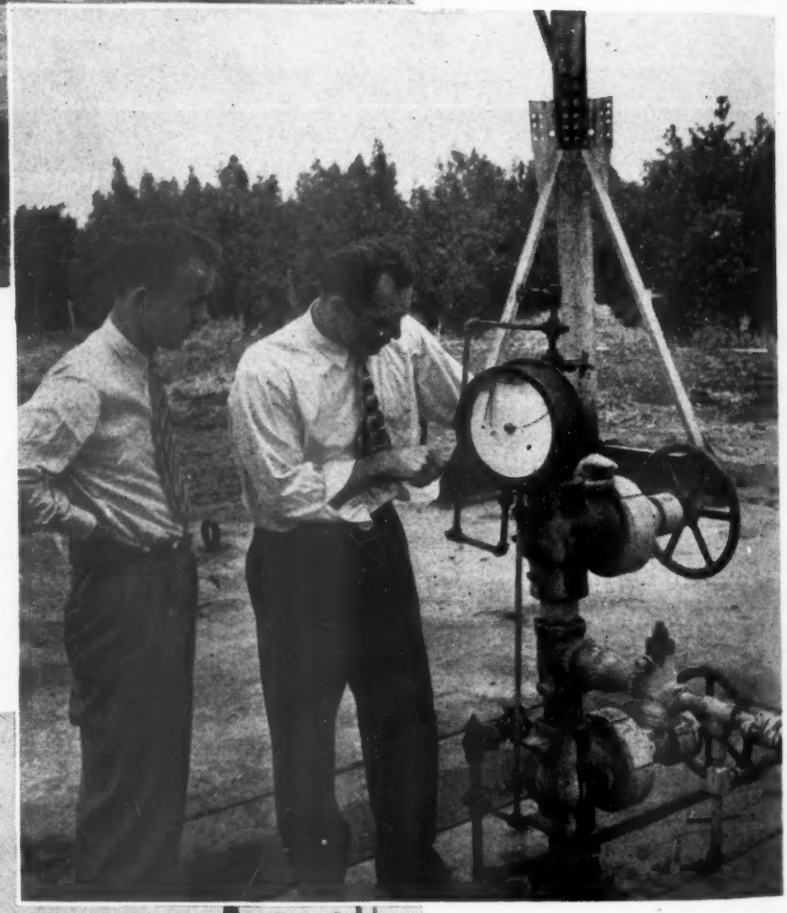

Wellhead at which both orifice and volumetric meters are used to measure injection rates. Checking the instruments are Charles Bowden and Harold Svoboda, engineers who operate the plant.

This pump is used for injection purposes and with the aid of back pressure regulators maintains uniform injection rates and pressures.

(Continued on Page 74)

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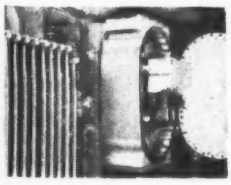

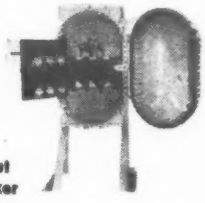

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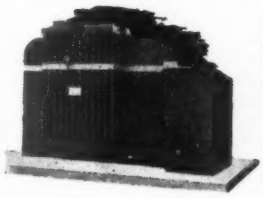

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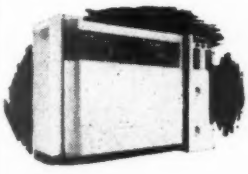
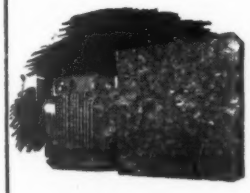


LOAD-CENTER UNIT SUBSTATION. G.E. offers units, in sizes from 100 to 2000 kva, equipped with either Pyranol* or dry-type transformers, depending upon your requirements. This unit substation for indoor service has a dry-type transformer.



D-C UNIT SUBSTATION. This d-c unit substation consists of completely metal-enclosed a-c switchgear, a transformer, and a metal-enclosed, sealed-ignitron mercury-arc rectifier with enclosed control, and d-c switchgear. Available in ratings of 75 to 500 kw at 250 volts and 100 to 1000 kw at 600 volts.

CONTROL-CENTER UNIT SUBSTATION. For centralized low-voltage control, a unit substation with Cabinetrol is recommended. Full-voltage, reduced-voltage, single-speed, multispeed, and reversing starters can be grouped and interlocked in any required sequence.

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(Continued from Page 70)

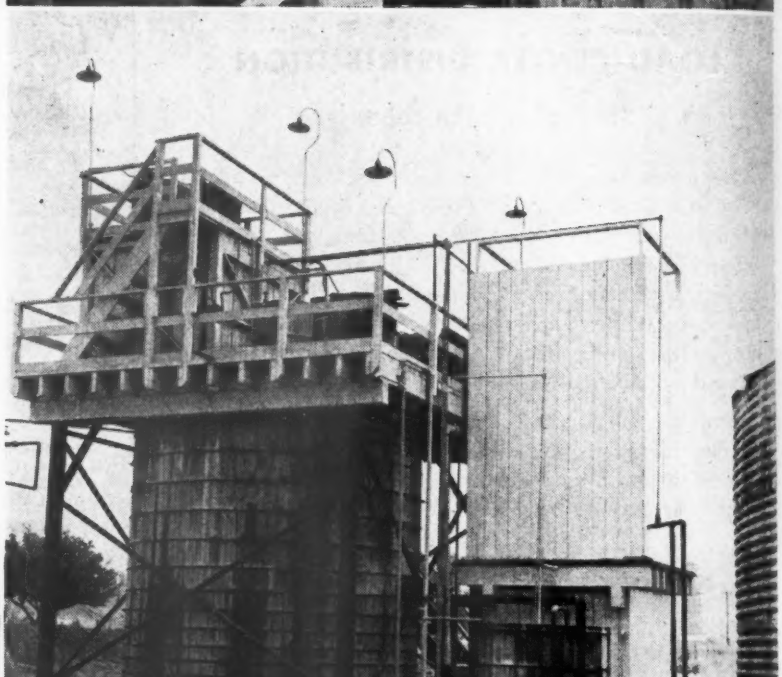
inner compartment, meanwhile being gently agitated.

The stream overflows this inner chamber into the annulus between it and the outer shell, under which it passes into a settling chamber. Sludge is drawn off the bottom of the flocculator. From the top of the settling chamber the water is forced to pass between closely spaced carbon electrodes, where it is chlorinated by action of the direct current on the chloride ions that it contains. The chlorinated water is conducted to a storage tank, whence as required it goes to the final flocculator. Both the flow to this unit and the treatment in the unit are as nearly automatic as they could well be.

Alum is again the flocculating medium and the treatment is practically the same as in the primary unit. After undergoing this process, the water is filtered through a sand bed and flowed out into a clear water storage basin, the filtration system also being fully automatic and fully protected against untimely interruption. For example, if the filter plugs the rising of a float operates an electrical timing switch, which takes care of the whole business in a series of logical steps until it is back in proper operation again.

For the actual injection, water from the clear water storage basin is pumped through 3500 ft. of 3-in. transite line to the suction of a triplex pump at the injection well. A back pressure regulator maintains a constant pressure on this line, and another similar regulator controls the injection rate through by-passing water from the discharge into the inlet line of the pump. The quantity of water injected is measured both by a volumetric meter and by an orifice meter.

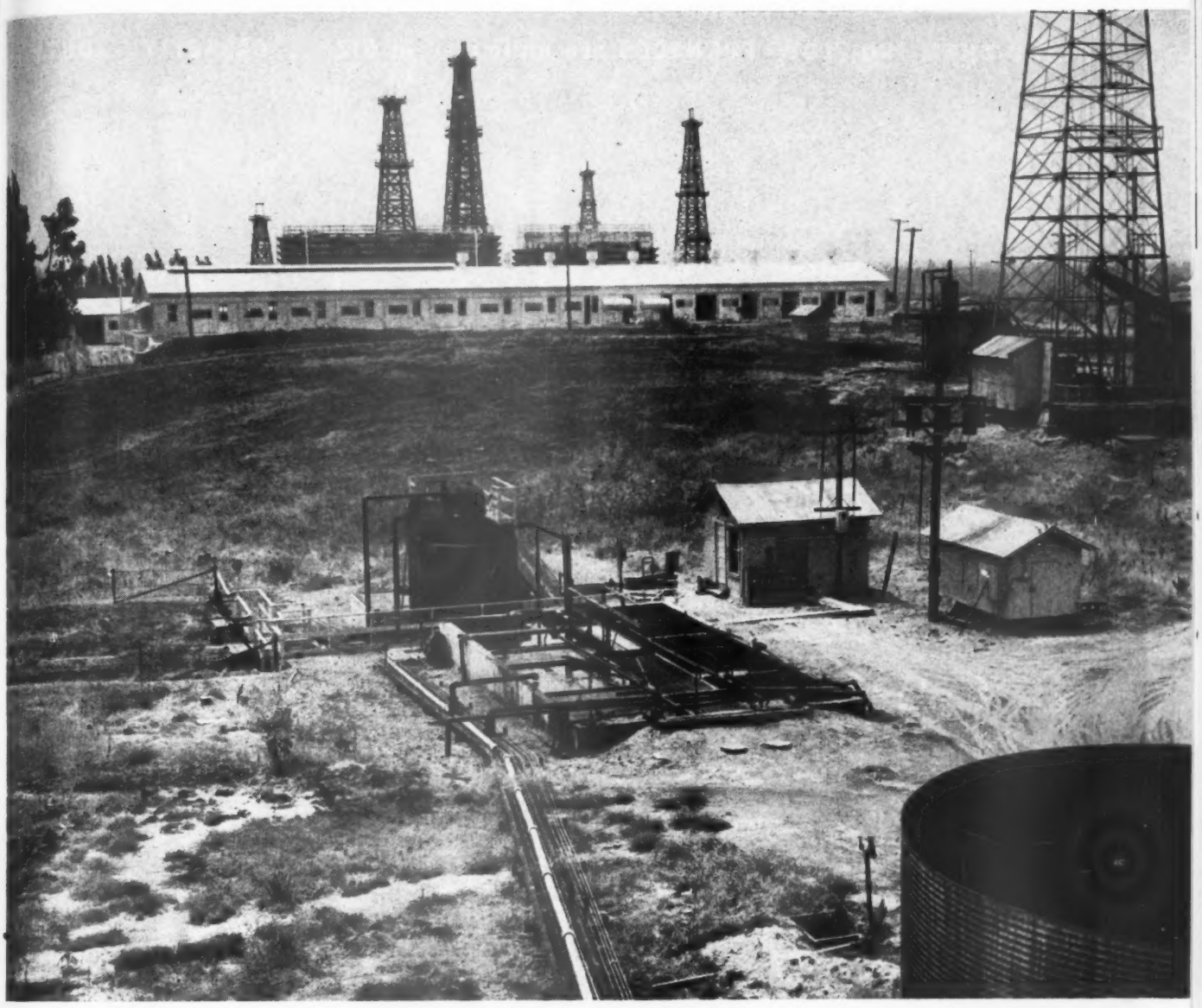
The entire system is so designed that



Top—Interior of field laboratory, showing control switches and apparatus for checking efficacy of water treatment.

Center—Primary flocculation unit where water is treated with alum and settled to dispose of suspended organic matter. It then passes through carbon electrodes and dissolved organic compounds are rendered flocculable.

Left—Secondary flocculation and filtration system with clear water storage basin at right.



Secondary flocculating and filtrating system with field laboratory and control house at right.

a very minimum of operators are required and nothing of any consequence can happen without the knowledge of one or more operators, even when they are considerably removed from the plant. Float switches on the semi-treated storage, filter, and clear water storage, set off an alarm when the occasion warrants, to which those concerned can respond so long as they are anywhere in the area.

Because of the experimental nature of this project every stage in the sequence of operations is subjected to frequent observation and, where necessary, test. As a result some very interesting conclusions are to be drawn. For instance, it has been noted that although the water leaving the chlorinator is completely sterilized, it is so quickly reinhabited by micro-organisms that the bacteria count of the injected water is many times that of the raw water. These are so numerous as to cause plugging of a sintered disk, but up to the present moment there is no evidence of plugging of the formation or well bore from any cause.

The official injection began on March 29, 1944, and since that time has remained relatively constant at approximately 100 bbl. per day. Minor difficulties have been encountered but so far they have always been capable of explanation and correction. The Kobe triplex pump used for injection had to be changed to some extent to meet the unusual conditions imposed. With a few minor adaptations, however, the pump has proved highly satisfactory.

Only one well has been submitted to the water flooding treatment and from an initial production of approximately 7 bbl. a day it rose over several months to 30 bbl. In the period that has elapsed since the experiment was begun, well over 5000 bbl. of oil have been produced in addition to that which would have been yielded under normal primary production methods.

From the available details of experience to date on this interesting piece of applied research a number of conclusions can be drawn. First, it is quite obvious that oil in the Chapman zone at Richfield can be displaced with water, and that water-flooding is an effective medium for secondary recovery in that section of the reservoir. Second, it has been demonstrated that water injection can be sustained over a considerable time, if flocculable material is first removed. No report has yet been forthcoming on the economics of the process—and it is, therefore, impossible to say whether or not the experiment as conducted on a small scale can be conducted on a large scale, profitably.

Another conclusion that can be drawn from this experiment is in the nature of a confirmation. It confirms the fairly well established fact that the oil industry is a logically-minded, forward-looking institution. This project is a sort of probe into the future. Union Oil Company has ample production to take care of its immediate needs, but as long as the right type of men are at the production helm, there will never be satisfaction on the basis of momentary satiation. It is this restless searching—this refusal to let tomorrow take care of itself—that has kept the oil industry always well to the forefront of scientific and technological development. ★★★

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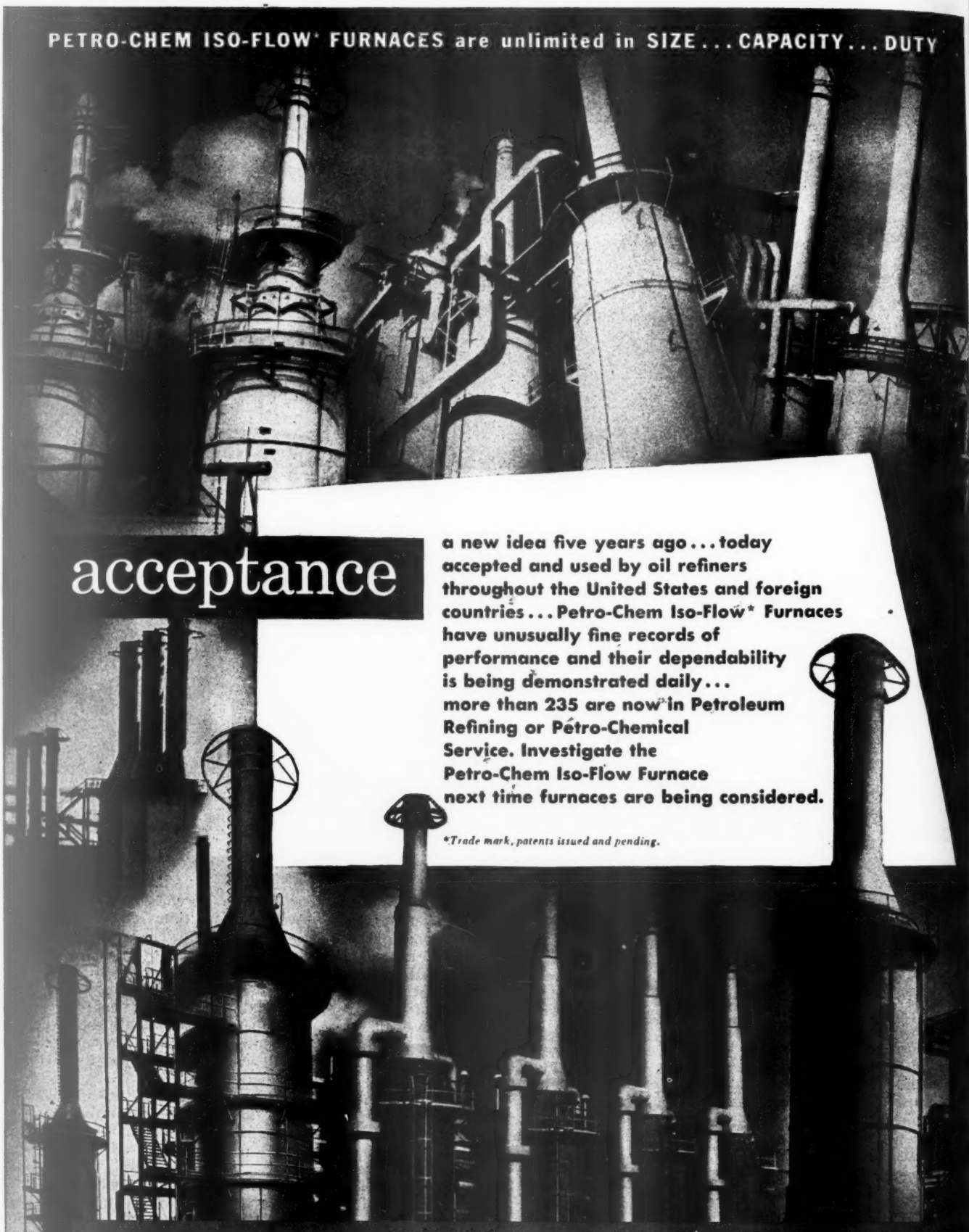

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MECHANICAL DRIVE STEAM TURBINES IN REFINERIES

By **DONALD R. JENKINS,** *Steam Engineer*
Westinghouse Electric Corporation

EXCLUSIVE DURING the war history was made by oil refineries. All planes, ships, tanks, and trucks that carried the war to the enemy could do so because their never ending thirst for fuel was satisfied by the product of oil refineries.

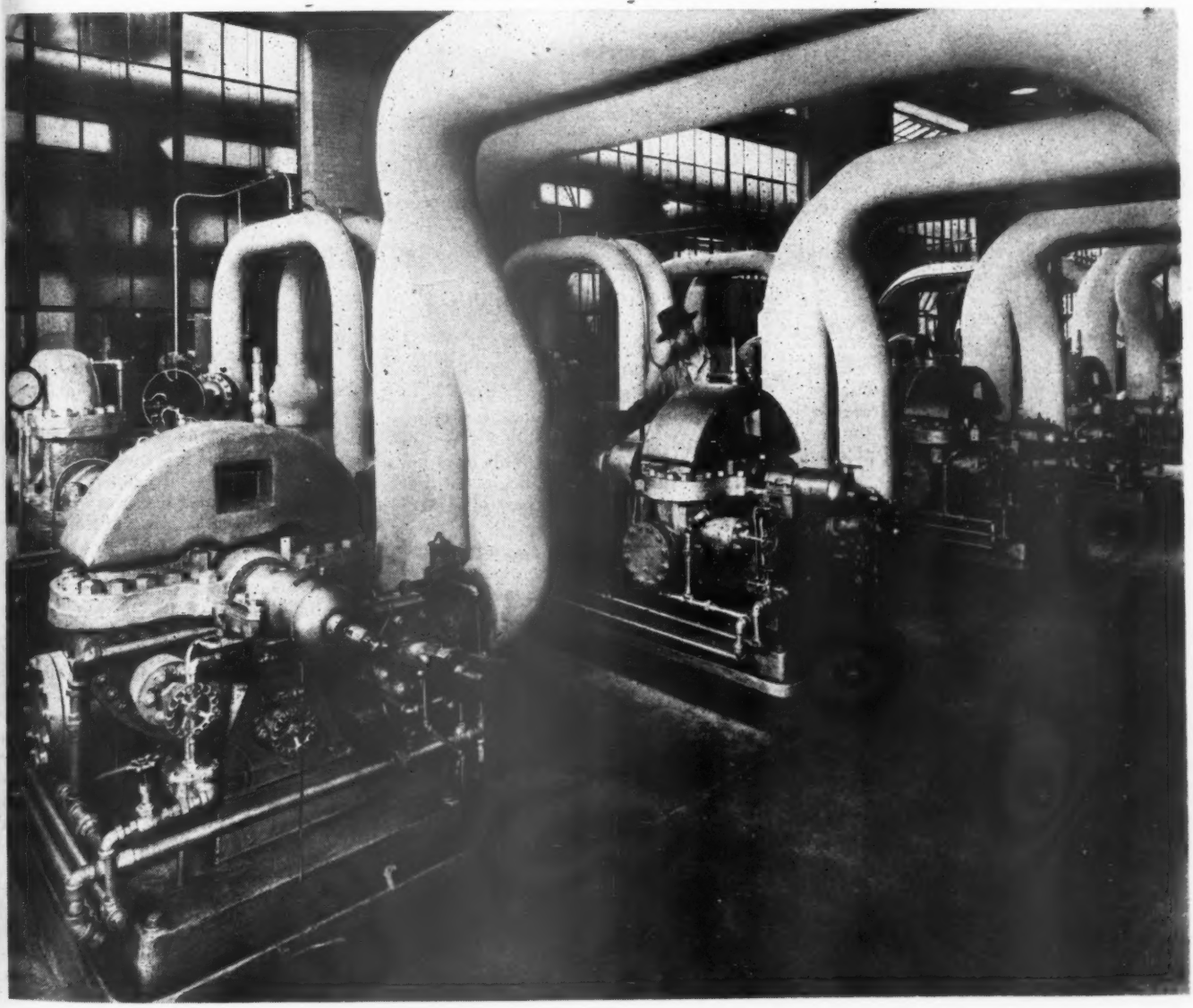
Refineries use large quantities of process steam at various pressures and temperatures. They also use large quantities of power to drive essential auxiliaries such as pumps and blowers. As steam must be generated at a pressure at least as high as the highest process pressure requirement, it is regular practice to use mechanical drive turbines to supply low cost by-product power, and low pressure steam for process use. In supplying these two needs standard mechanical drive turbines can operate on any available steam supply.

Single-stage mechanical drive turbines having relatively high steam consumption are best applied where there is use for the exhaust or for inexpensive but reliable standby drive. Most mechanical drive turbine applications in refineries are of less than 500 hp., in which range a single-stage turbine is usually the most economical. Multi-stage turbines are regularly used on continuous duty units of more than 500 hp., and occasionally, when low steam consumption is justifiable, on small units. Continuous duty drives are generally selected on the basis of evaluated steam costs and standby drives on the basis of first costs. The range of frame sizes on single-stage turbines and the stage combinations on multi-stage turbines provide a suitable choice for selecting the required efficiency to develop economically the required horsepower.

Occasionally circumstances may make it necessary to operate mechanical drives condensing. Sometimes single-stage turbines exhaust into a condenser when they are used as standby drives. Continuous duty condensing turbines usually justify higher efficiency multi-stage units.

Where many of the refinery drives are electrically driven from the refinery's own power plant or from purchased power the important ones usually have

FIG. 1. Typical refinery application boiler feed pumps.



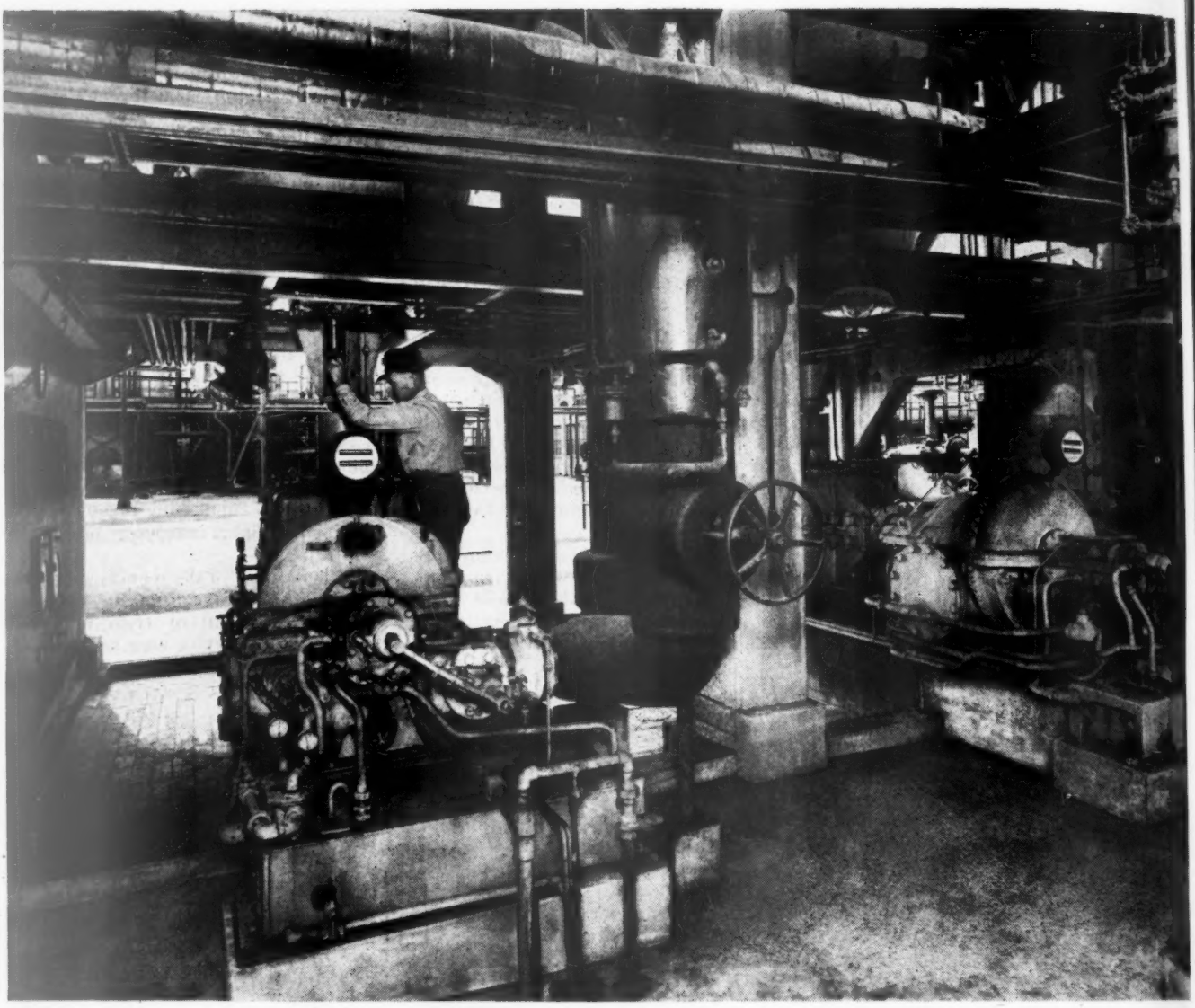


FIG. 2. Stratford contactor drives.

a steam standby. In refineries operating on purchased power a small automatic starting turbine generator set is almost always used to supply power for the essential drives in case of electrical outage.

The mechanical drive turbine has many desirable characteristics that make it ideal for use in refineries. Ease of providing adjustable speed control through the use of an adjustable speed governor with either a direct acting or relay operated governor perhaps heads the list. A turbine can also be very easily tied in with external control systems to provide pressure, flow, volume, or temperature control of the driven apparatus. These controls can operate through the turbine governing system or they can operate an independent regulating valve in the line ahead of the turbine.

A mechanical drive turbine can be designed to operate at any speed to match the best characteristics of the driven machine. This may sometimes require a reduction gear for low speed driven equipment. On high speed equipment the turbine can be directly connected.

Danger of fires or explosions from sparking is eliminated by making the overspeed trip sparkless.

Simplicity of operation and low maintenance as compared to other types of machinery is outstanding. This does not mean the turbine can be neglected, but with reasonable care the best of service can be obtained.

Care in *installation*, *operation*, and *maintenance* is just as important for mechanical drive turbines in an oil refinery as for large turbines in a power plant. Each turbine driving a pump or special drive must help keep the refinery on stream at all times during the refinery's operation period.

Low-cost power and low-pressure steam make these turbines efficient for use in oil refineries.

When the turbine is first received from the manufacturer it is most important to inspect it for possible damage incurred in transit. It is also necessary to remove all protective coatings, slushing compounds, and greases used to protect the turbine during shipment. All bearing cavities, steam openings, and steam lines should be checked to see that they are clean and free. In the case of pumps, or similar machinery, the turbine and the driven machine are usually mounted on a common bed-plate. When this is the case, the coupling bolts are usually removed and either the driver or driven unit is dowelled for shipment. The other is dowelled after final alignment. This practice is followed to assure correct alignment of the units before placing in operation. The shaft ends and couplings must be properly aligned in accordance with the manufacturer's instructions before bolting them up. Unsatisfactory operation or even damage will result from faulty coupling alignment. →

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To small refiners

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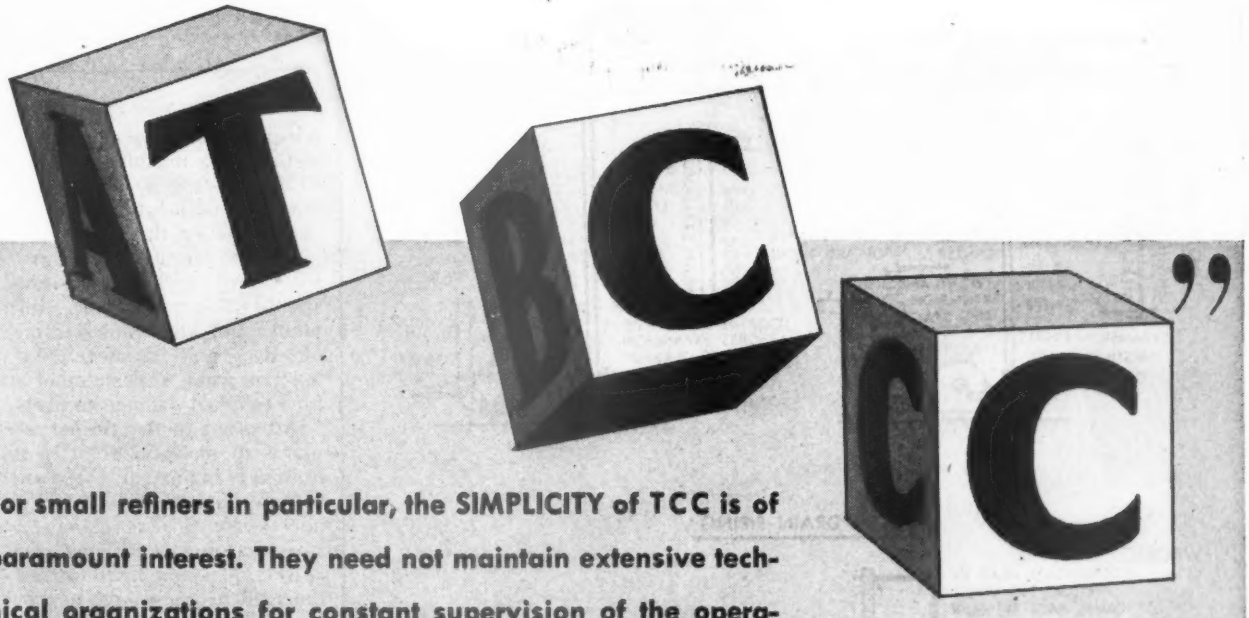

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● **Installing mechanical drive turbines.** Fig. 3 shows the *right* and *wrong* ways to install mechanical drive turbines. If the upper right hand side of the chart is followed on installation, the turbine will operate free from vibrations ordinarily caused by improperly installed piping. The steam inlet should always come off the top of the steam header so that the entire steam line will not drain into the turbine. The steam inlet pipe should be supported as noted on the right-hand side of the chart in order that the weight and expansion of the pipe will not twist the turbine. An expansion joint should be used between the turbine flange and the exhaust pipe, and the large pipe should also be supported as illustrated in the chart. Because of the relative size of the pipes to the size of the turbine, a criterion that should be followed is that, when heated up to normal operating temperature and unbolted from the turbine flanges, the inlet and exhaust piping should not spring away from the turbine or out of line from it. This condition should exist if the piping is arranged as illustrated on the "right" side of the chart (Fig. 3).

Drains, the cylinder and gland drains, must be properly installed. These drain lines should be both short and sloping in order to carry away the drainage properly. The drainage can be taken either to an open tank at atmospheric pressure or to the sewer. The piping should not contain pockets and should be of ample size to handle all drainage. The piping and cylinder drains should always be opened after shutdown to assure complete drainage of the unit. These drains should not be closed until they blow dry steam when starting up the turbine.

It is most important that the turbine itself be bolted securely to the foundation, or the pump and turbine if on a common bed-plate. This bolting to the foundation must be done in such a manner that it will not effect the alignment of the units. In this respect it is important to remember that a three-point support is the ideal condition. As three points in space determine a plane, a unit supported at three points may be shifted bodily, but will remain in the same plane and therefore minimize internal distortion in the structure. Sometimes machines are supported at four points and this is satisfactory if the foundation is adequate. Extreme care must be used in setting up a machine on four points.

TABLE 1.

Mechanical drive turbine applications.

PUMPS
- Water
  - Boiler feed
  - Condensate
  - Condenser circulating water
  - Heater drains
  - Fresh water
- Chemical
- Oil
  - Hot and cold oil

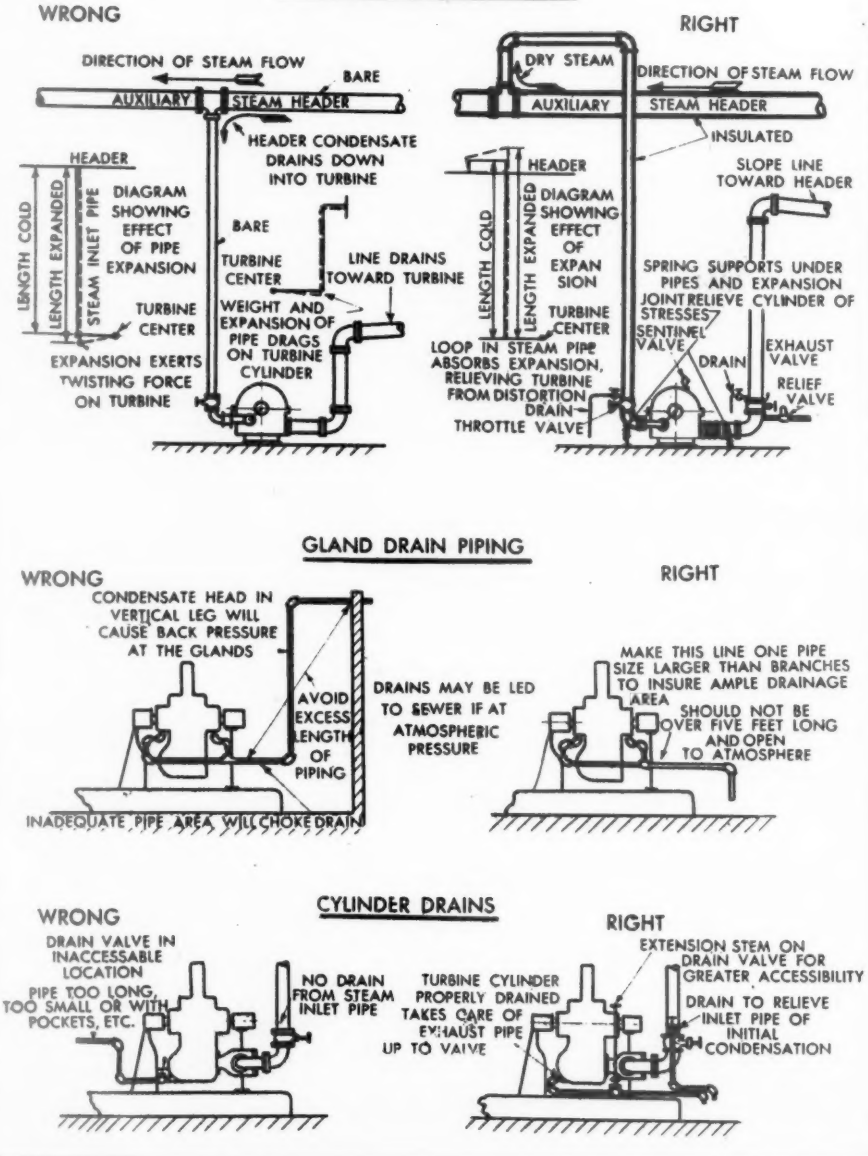
FANS
- Boiler
  - Induced draft
  - Forced draft
- Ventilating fans
- Catalyst regenerator blowers

SPECIAL DRIVES
- Houdry gas turbine starting turbine
- Stratford contactor units
- Refrigeration compressors

Many times it is necessary to store machines on location before they are installed. When this is the case, it is important to see that each unit is well protected. All exposed mechanical surfaces should be covered with slushing compound and all steam openings blanked off. It is very important that workmen use care when working on or about a turbine to avoid damage to parts.

Attention to the proper use of hand valves in mechanical drive turbine operation is important. Fig. 4 shows a typical mechanical drive turbine performance curve of load versus steam flow at two operating conditions; that is, hand valves open and hand valves closed. If the load decreases the steam flow must be decreased to balance the change in load. This is accomplished automatically by the throttling control of the governor valve, which is positioned by the turbine governor. Throttling by any means causes a loss in efficiency but at partial loads this loss can be minimized by the use of hand valves that close off a group of nozzles thus reducing the nozzle area. The result is a reduction in steam flow at partial loads due to the improvement in nozzle efficiency. Another advantage in using hand valves at partial loads is that more stable governing results from operation with the increase in governor valve lift that accompanies the reduction in flow. Hand valves are also used to adjust the nozzle area for changes in steam conditions; and thus obtain more efficient and more stable operation. Regardless of whether hand valves are used the governor con-

FIG. 3. Right and wrong installation chart.


STEAM AND EXHAUST PIPING
WRONG
DIRECTION OF STEAM FLOW
BARE
AUXILIARY
STEAM HEADER
HEADER CONDENSATE DRAINS DOWN INTO TURBINE
HEADER
LENGTH COLD
LENGTH EXPANDED
STEAM INLET PIPE
DIAGRAM SHOWING EFFECT OF PIPE EXPANSION
BARE
TURBINE CENTER
LINE DRAINS TOWARD TURBINE
TURBINE CENTER
WEIGHT AND EXPANSION OF PIPE DRAGS ON TURBINE CYLINDER
EXPANSION EXERTS TWISTING FORCE ON TURBINE
RIGHT
DRY STEAM
DIRECTION OF STEAM FLOW
AUXILIARY
STEAM HEADER
INSULATED
HEADER
SLOPE LINE TOWARD HEADER
LENGTH COLD
LENGTH EXPANDED
DIAGRAM SHOWING EFFECT OF EXPANSION
SPRING SUPPORTS UNDER PIPES AND EXPANSION JOINT RELIEVE CYLINDER OF STRESSES
TURBINE CENTER
SENTINEL VALVE
DRAIN
EXHAUST VALVE
RELIEF VALVE
LOOP IN STEAM PIPE ABSORBS EXPANSION, RELIEVING TURBINE FROM DISTORTION
DRAIN
THROTTLE VALVE
GLAND DRAIN PIPING
WRONG
CONDENSATE HEAD IN VERTICAL LEG WILL CAUSE BACK PRESSURE AT THE GLANDS
AVOID EXCESS LENGTH OF PIPING
DRAINS MAY BE LED TO SEWER IF AT ATMOSPHERIC PRESSURE
INADEQUATE PIPE AREA WILL CHOKE DRAIN
RIGHT
MAKE THIS LINE ONE PIPE SIZE LARGER THAN BRANCHES TO INSURE AMPLE DRAINAGE AREA
SHOULD NOT BE OVER FIVE FEET LONG AND OPEN TO ATMOSPHERE
CYLINDER DRAINS
WRONG
DRAIN VALVE IN INACCESSABLE LOCATION
PIPE TOO LONG, TOO SMALL OR WITH POCKETS, ETC.
NO DRAIN FROM STEAM INLET PIPE
TURBINE CYLINDER PROPERLY DRAINED TAKES CARE OF EXHAUST PIPE UP TO VALVE
RIGHT
EXTENSION STEM ON DRAIN VALVE FOR GREATER ACCESSIBILITY
DRAIN TO RELIEVE INLET PIPE OF INITIAL CONDENSATION

#3 in a series of advertisements discussing postwar refining processes.

NAPHTHA REFORMING FOR POSTWAR COMPETITIVE MARKETS

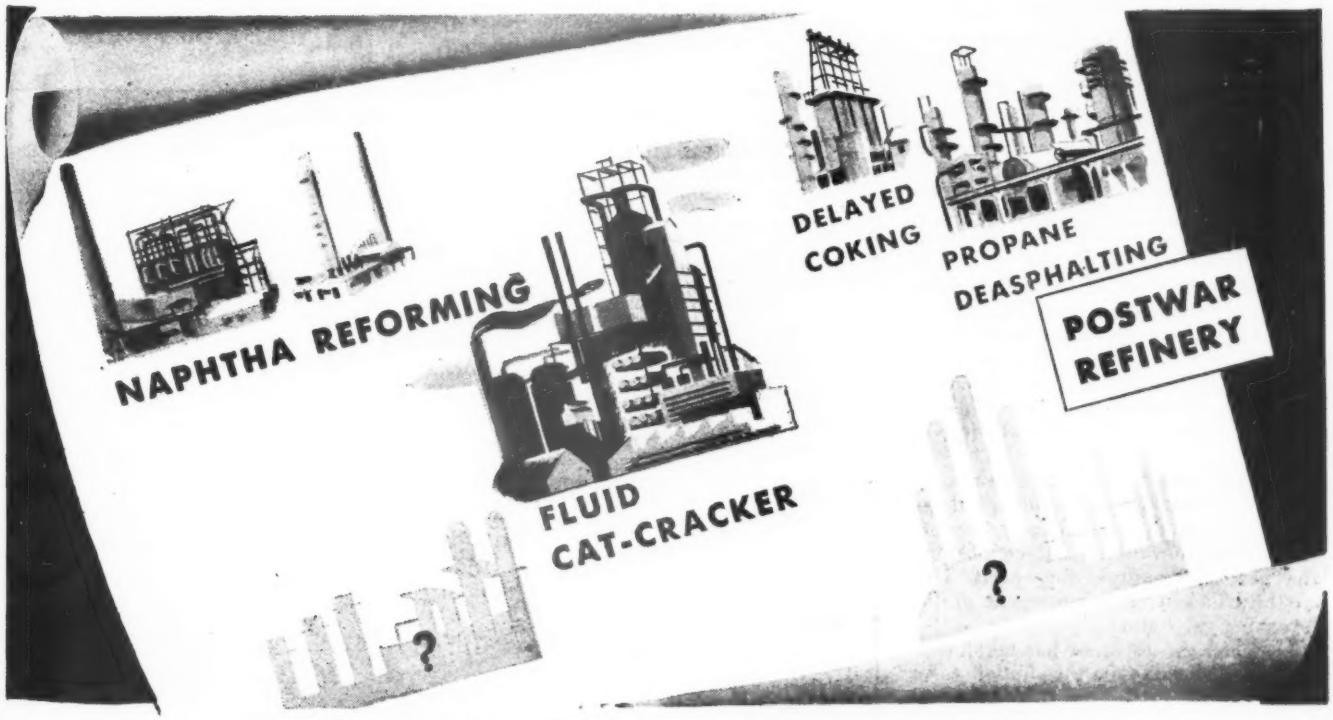
AMONG PETROLEUM marketing analysts the consensus is that postwar, house-brand gasolines will have at least an 80-octane (CFR-M) rating, while premium products will, of course, have even higher ratings.

With this trend in the making, refiners are now giving serious thought to postwar projects involving the stepping up of low grade naphthas. Three methods suit most requirements. (1) reversion, i.e., thermal reforming in combination with thermal polymerization. (2) thermal reforming with or without catalytic polymerization. (3) catalytic reforming or hydroforming.* The relative desirability of these methods is dependent, obviously, upon the octane level required, basic feeds, and cracking and reforming equipment currently available.

One of the surest ways for refining managements to safeguard capital investments and reach the *profitable* decision regarding choice of these alternate methods of reforming is to undertake a thorough economic analysis of overall operations. For years, M. W. Kellogg has emphasized this economic approach to engineering design and installations.

If naphtha remodernization is on your calendar . . . Kellogg engineers will be glad to help you put your project on the profits side of the ledger.

*Kellogg has designed and built *over 90 per cent* of the country's entire hydroforming capacity.



THE M. W. KELLOGG COMPANY

Engineers and Economists to the Petroleum Refining Industry

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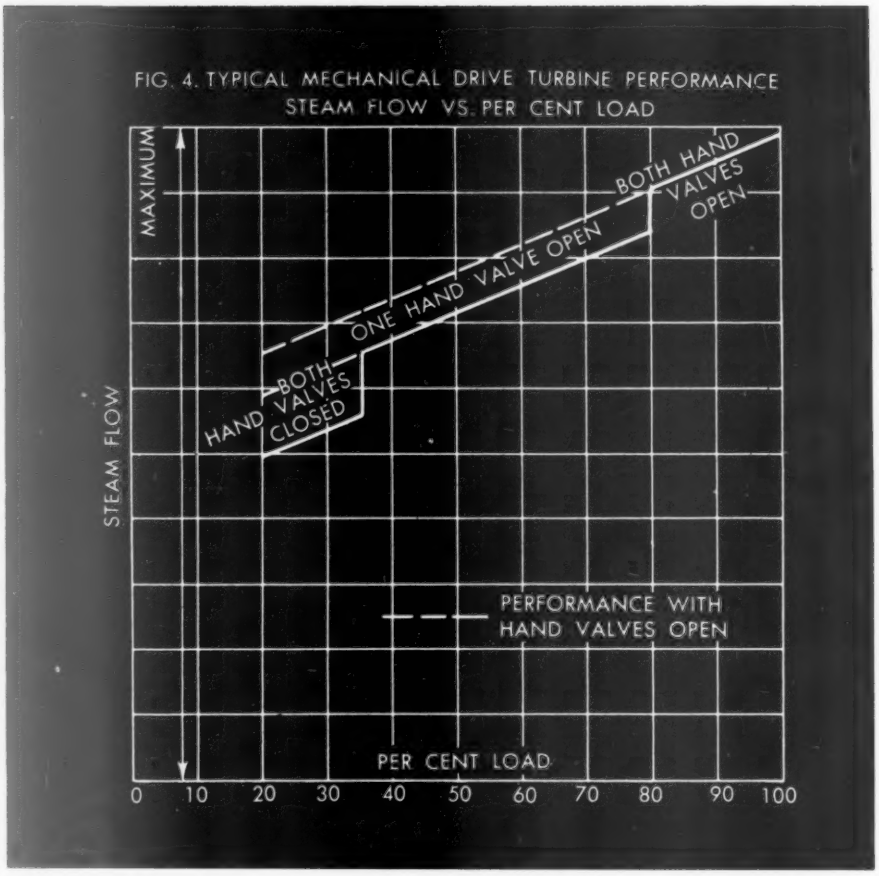


FIG. 4. TYPICAL MECHANICAL DRIVE TURBINE PERFORMANCE
STEAM FLOW VS. PER CENT LOAD
MAXIMUM
STEAM FLOW
BOTH HAND VALVES OPEN
ONE HAND VALVE OPEN
BOTH HAND VALVES CLOSED
PERFORMANCE WITH HAND VALVES OPEN
PER CENT LOAD
0 10 20 30 40 50 60 70 80 90 100

trols all the steam to the turbine. Operators should be instructed to use the hand valves when the load conditions warrant their use.

The following outline of operation and maintenance lists the manufacturer's recommendations for obtaining reliable, trouble-free performance.

● **Operation.**

To start:

1. Open the drains from the steam inlet and exhaust lines, and be sure these lines are free of condensate.
2. Be sure all casing drains are open.
3. Open the exhaust valve.
4. Open the shut-off valve sufficiently to start the turbine rolling.
5. Close the hand-controlled drains when it becomes certain that the parts that they drain are free of condensate and the turbine is heated sufficiently to prevent additional accumulation of water.
6. Open the shut-off valve gradually to increase the speed. As the speed approaches normal, see that the governing valve moves toward the closed position and properly controls the speed. This can be checked from movement of the governing valve stem.
7. When the governor has taken control of the speed, open the shut-off valve wide.

To shut down:

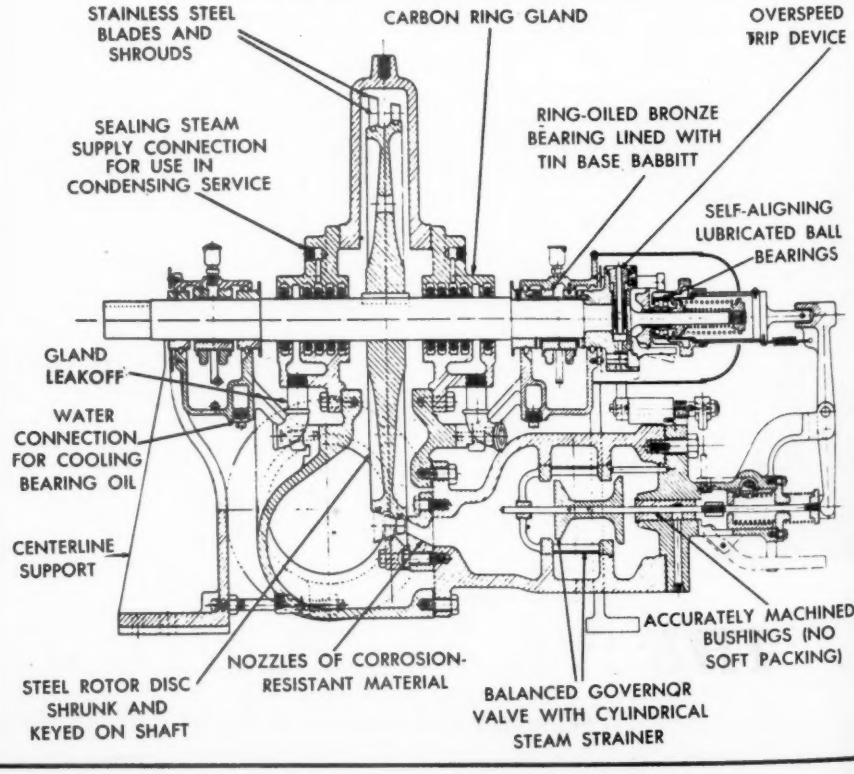
1. Trip the overspeed trip by hand. This is the easiest way to stop the turbine and will test the trip mechanism. This tests only the trip linkage and quick closing valve, however, and does not check the speed at which the overspeed trip weight functions.
2. Close the shut-off valve.
3. Reset the overspeed trip mechanism, thus putting it in the correct position for the next starting period.
4. When the turbine comes to rest, close the exhaust valve and *open all drains between the shut-off valve and exhaust valve.*

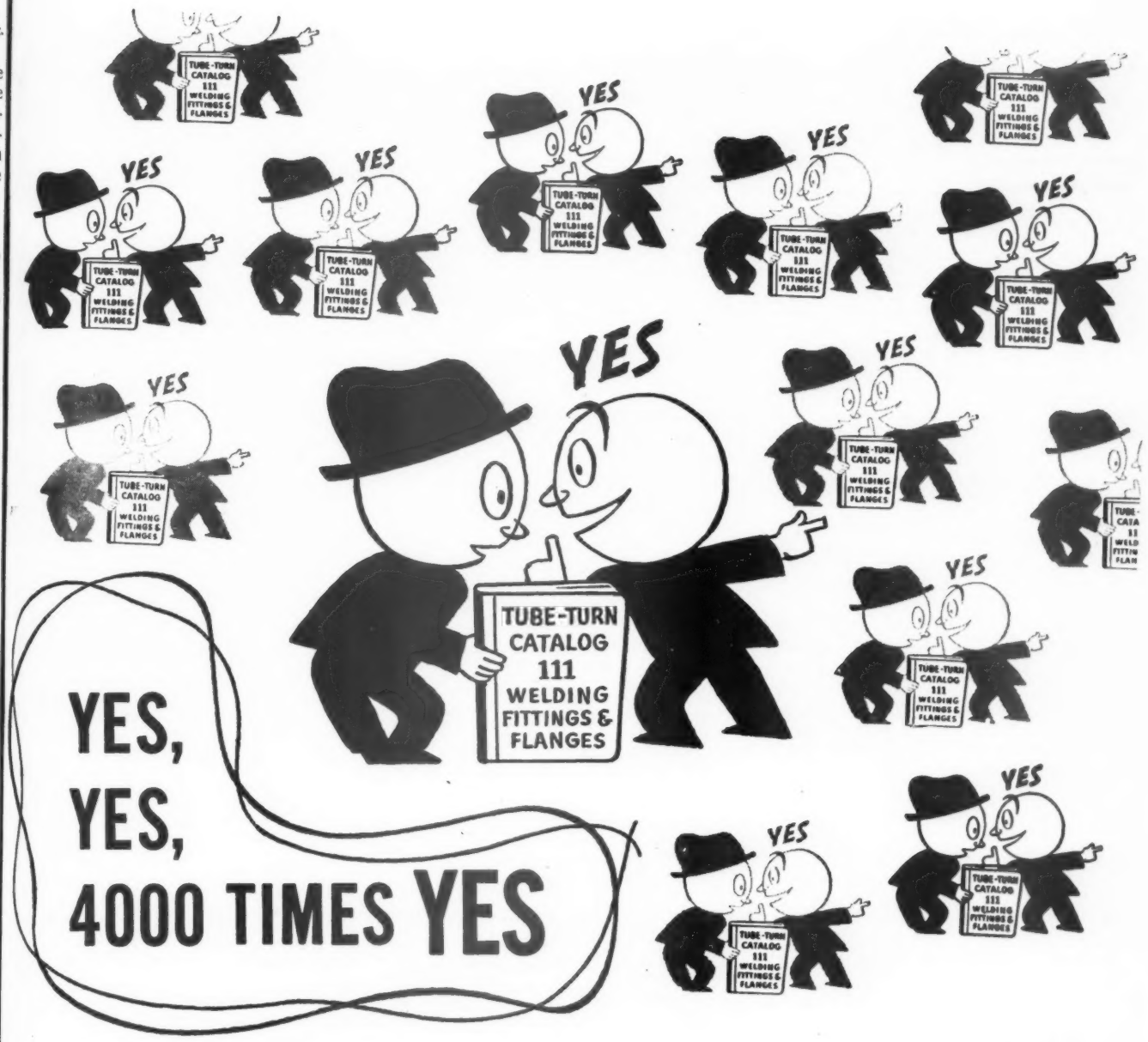
Precaution. Keep the exhaust valve closed and all casing drains open while the turbine is shut down. This is of utmost importance to prevent the accumulation of condensate in the casing, which might cause corrosion and impair the future operation.

● **Maintenance.**

1. Keep the machine clean. Keep paint off the moving and sliding parts; that is, valve stems, governor stems, speed changer screw, etc.
2. Clean the governing valve stem and butterfly valve stem as often as necessary, to prevent the accumulation of boiler compound or other foreign matter due to normal operation. These parts must be kept working freely.
3. Keep the shut-off valve in good condition and steam tight, in order to prevent steam leakage into the turbine during shut downs. All drains must be kept open when the machine is shut down.
4. Trip the overspeed trip occasionally to see that it is in good working condition.
5. Occasionally check the tripping speed with tachometer to see that overspeed trip is not stuck.
6. Check oil level and do not over lubricate or allow water to contaminate oil supply.
7. Keep lubricating system free from dirt and foreign matter.
8. Keep drainage lines from glands clean and occasionally refit carbon glands after normal wear.
9. After any disassembly be sure to reassemble as per instruction book directions. ★★★

FIG. 5. Typical cross-section C-25 turbine.


STAINLESS STEEL BLADES AND SHROUDS
CARBON RING GLAND
OVERSPEED TRIP DEVICE
SEALING STEAM SUPPLY CONNECTION FOR USE IN CONDENSING SERVICE
RING-OILED BRONZE BEARING LINED WITH TIN BASE BABBITT
SELF-ALIGNING LUBRICATED BALL BEARINGS
GLAND LEAKOFF
WATER CONNECTION FOR COOLING BEARING OIL
CENTERLINE SUPPORT
ACCURATELY MACHINED BUSHINGS (NO SOFT PACKING)
NOZZLES OF CORROSION-RESISTANT MATERIAL
STEEL ROTOR DISC SHRUNK AND KEYED ON SHAFT
BALANCED GOVERNOR VALVE WITH CYLINDRICAL STEAM STRAINER



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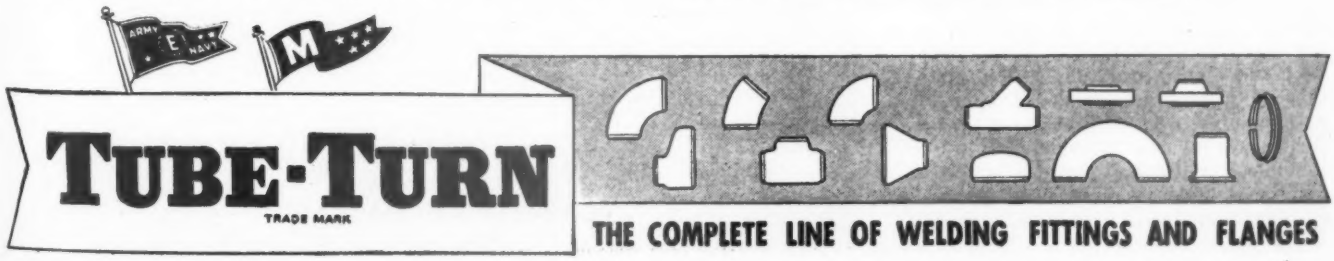

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VOCATIONAL CLASS PROCEEDINGS

INSTALLMENT NO. 11

EXCLUSIVE THE principal characteristics of a centrifugal pump are as follows:

(a) Smooth, even flow.

(b) A drop in pressure or head increases capacity and power consumption.

(c) Increase in head reduces capacity and power consumption. The effect of shutting the discharge valve is to increase the pressure from 15 to 30 per cent and reduce the power from 50 to 60 per cent.

As a result of this characteristic, a centrifugal pump makes a very easy load for any driving unit. The torque required to start the pump is very small, whereas the operating load is smooth and free from shock.

Because of the varying characteristics of a centrifugal pump it is frequently desirable for the operator to see the graphic picture of the relationship between head, capacity, horsepower, etc., of the pump under consideration.

Fig. 69 is typical and illustrates the performance of a pump operated at constant speed. The line sloping downward from left to right represents the varying quantities of liquid delivered by the pump with variations in head or pressure. The intersection of this line with the zero delivery line shows the head or pressure developed by the pump when the discharge valve is shut.

The curve showing the horsepower to drive the pump slopes upward in the opposite direction with the lowest point at the shutoff of the pump. (See characteristic curves of double suction—single stage pump, Fig. 70.) These two lines show the complete performance of the pump for the one speed for which the curve is plotted. For convenience, however, another curve showing the efficiency of the pump may be plotted on the same sheet. This efficiency curve shows the amount of usable work done by the pump in per cent of power delivered to pump shaft. (If the efficiency at any given point is subtracted from 100 per cent it will show the per cent of the power applied to the pump shaft that is lost within the pump at that point.)

Pumps of identical design will have almost identical characteristics, with only slight differences due to unavoidable foundry variations, etc. Pump curves can be plotted to show variations with changes of speeds as well as changes in heads and capacities. Most electric motors operate at constant speed, however, so that the usual practice is to show the pump characteristic for a single speed suitable for the conditions under consideration. The changes in capacity, head and horsepower for various speeds may be calculated.

When a centrifugal pump is operated with a positive pressure head applied to its suction, it will utilize this pressure. In other words, if a pump is capable of developing 100 ft. of head and the liquid reaches the pump under a positive head or pressure of 25 ft., the pressure or head developed at the discharge will be 125 ft. This is a very useful quality as two or more pumps of similar capacity can be operated, one discharging into the other to develop a total head that is the sum of the heads developed by the individual pumps. A variation of such series operation is found in mines and tall buildings where pumps are sometimes operated in series even though they are situated at different levels. This arrangement permits the use of low pressure pump cases at the high levels.

Large municipal water plants are usually arranged with large capacity low pressure pumps delivering into the mains, and with boosters at various outlying points. Frequently duplicate pumps are connected and valved so that higher pressure will be available for fire protection.

One of the accompanying curves (Fig. 72) covers the performance of a centrifugal pump operated singly, and also the method of plotting the performance of two identical pumps operated in series.

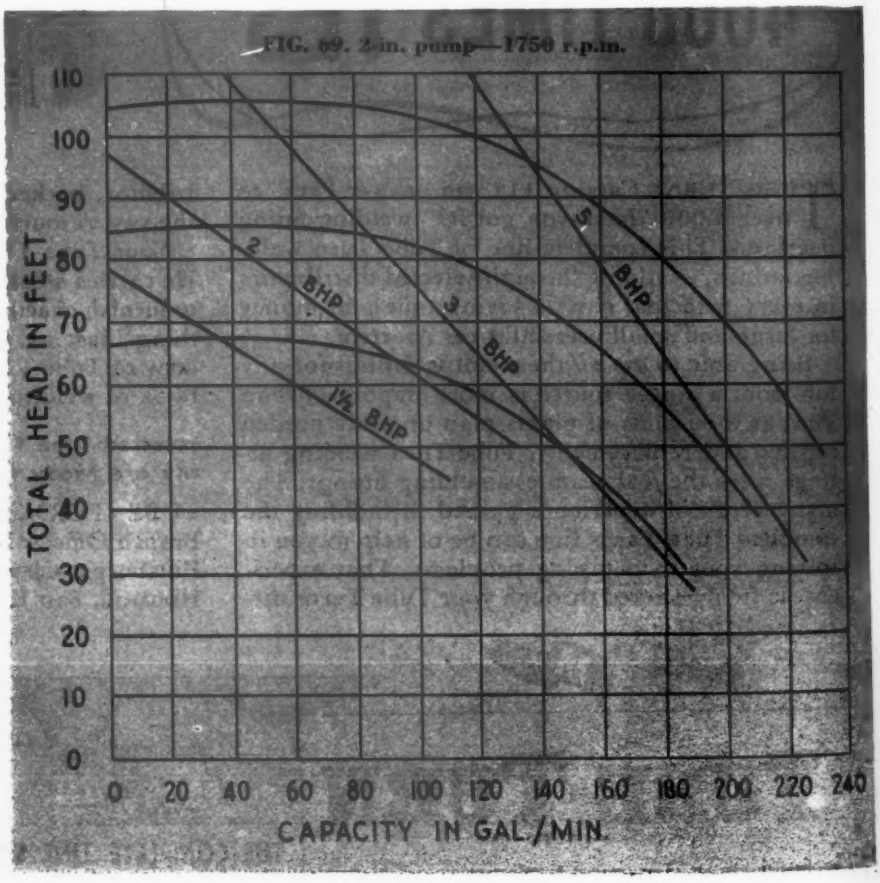
One of the curves (Fig. 73) shows the method of determining the capacity of two identical pumps operated in parallel. Pumps of different capacities can be satisfactorily operated in parallel if they have similar general characteristics. This can be best determined by combining the curves of the two pumps by the method shown here.

Pumps having a rated capacity may vary widely; for instance, one pump purchased for 100 ft. head may develop a shutoff head of only 115 ft., whereas another pump for the same head and speed may develop 130 or 140 ft. shutoff heads. These differences in centrifugal pumps are graphically illustrated in the characteristic curves supplied by the manufacturers. A pump is said to have a steep characteristic when the shutoff head is much more than the operating head.

Similarly, a pump is said to have a flat characteristic when the shutoff head is slightly more than the operating head.

The question is often asked whether it will be possible to substitute a higher speed motor of the next larger size in order to obtain additional capacity from an existing pump. Examination of centrifugal pump characteristics indicates that small increases in speed require considerable increases in power. The changes in capacity, head, and horsepower may be calculated. The reason for this is that if the impeller diameter

FIG. 69. 2-in. pump—1750 r.p.m.



Chalk up another Recordbreaker ...KEPT STRAIGHT BY TOTCO RECORDERS

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Again, as in nearly every other record-breaking well, Totco Recorders have helped guide the drill bit straight down to a new record for depth —16,724 feet! But more important are the thousands of every-day wells, deep and shallow, which have been drilled straighter, faster, cheaper, with Totco Recorders and Totco Controlled Vertical Drilling Methods. For more than ten years the experience of major oil companies and drilling contractors, drilling under all conditions in all parts of the world, shows that TOTCO RECORDERS AND TOTCO CONTROLLED VERTICAL DRILLING METHODS, WILL KEEP **YOUR** WELLS **UNDER 2°.**

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KCL 20-13
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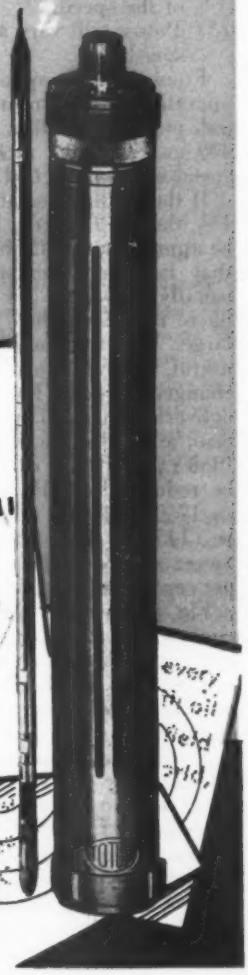
PHILLIPS PETROLEUM
ADA PRICE #1
15,047 FEET
May 1944

TOTCO RECORDERS
HELPED DRILL
CONTINENTAL OIL
KCL A-2
15,004 FEET
1938



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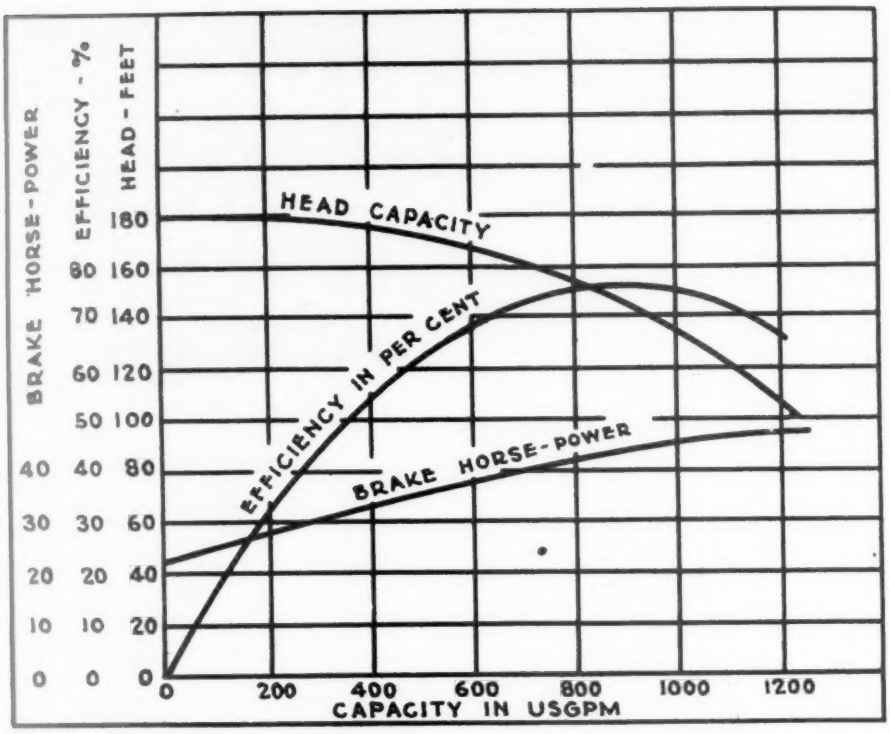


FIG. 70. Characteristic curves of double suction single stage pump.

is unchanged, the following relationship will occur:

(1) The quantity of water delivered will vary directly as the speed.
(2) The heads will vary as the square of the speed.
(3) Power will vary as the cube of the speed.

From this it is apparent that a pump operating at 850 r.p.m. delivering 200 gal. per min. at 20-ft. head will deliver 400 gal. per min. at 80-ft. head if the speed is increased to 1700 r.p.m.

If the horsepower at the 850 r.p.m. is 1½, the power at the higher speed will be approximately 12. From this it is seen that large changes of speed are not usually practical as the mechanical parts may be either too small or too large. The relationship above is very useful, however, when considering small changes in speed. For instance, a pump delivering 500 gal. per min. at 100-ft. head at 1750 r.p.m. is to be operated at 1450 r.p.m. In this case the capacity will be reduced to 415 gal. per min. ($1450 \div 1750 \times 500 = 415$.) The head will be $(1450 \div 1750)^2 \times 100 = 68$ ft. The power will be $1450 \div 1750$ cubed or 47 per cent of the original power.

Fig. 69 shows a 2-in. pump with full size and cut impeller performance. It is not advisable to use cut impellers because of the possibility of accidently replacing with an impeller of incorrect diameter.

A centrifugal pump operates most satisfactorily under a head and at a speed approximately that for which it was designed. The operating conditions therefore, should be determined as accurately as possible.

The total head or pressure (this is usually called total dynamic head) is made up of the following:

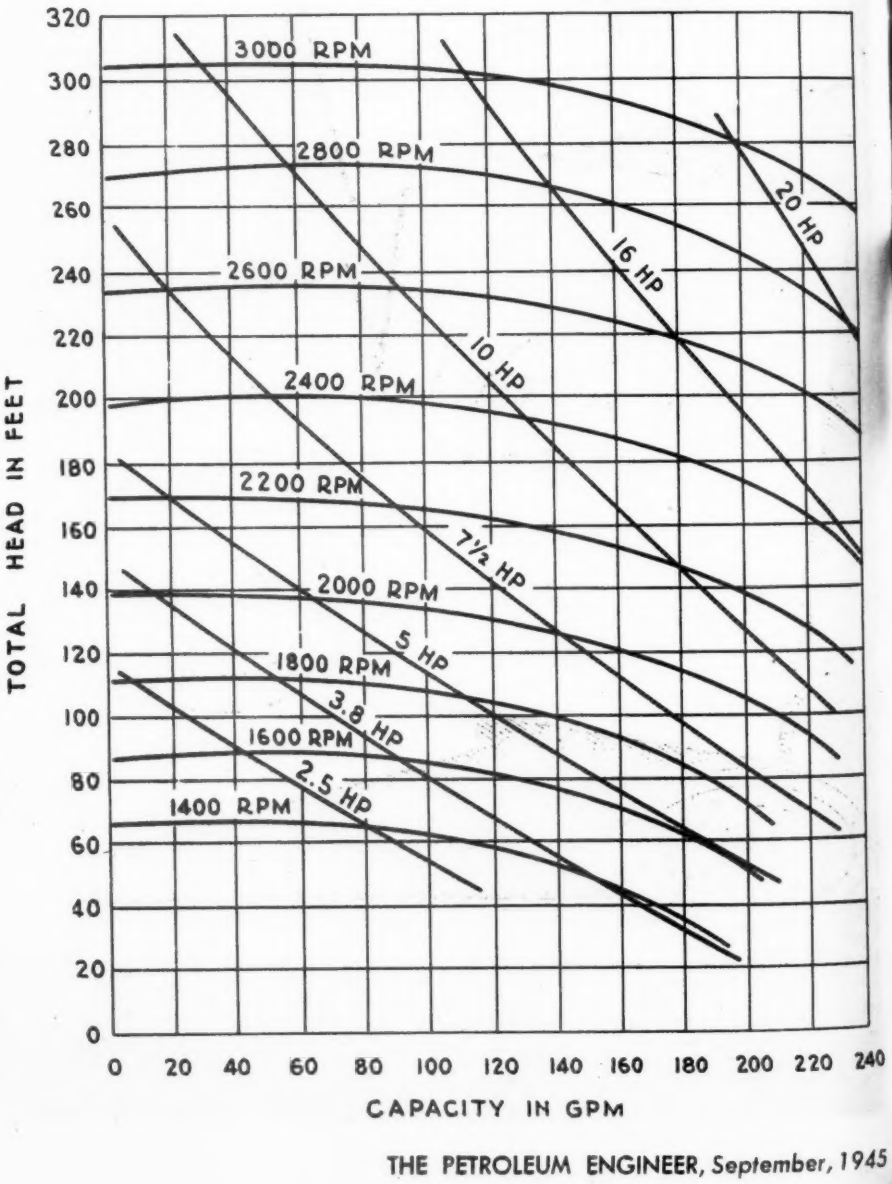
(1) Total static head of discharge above the level of suction water.
(2) Pressure required at point of discharge.
(3) Pipe friction.
(4) Suction—if fluid is to be lifted from a point lower than pump, add the amount of lift to the other components of the head. If fluid flows from above the pump or is delivered to pump under pressure, then the suction head or pressure is a deduction from the sum of the other head components.

In totaling the above figures any pressure expressed in pounds per square inch should be converted into feet of head. This is done by multiplying by 2.31. If the suction lift is expressed in inches of vacuum (mercury) it should be converted into feet of water by multiplying 1.13 (1 in. mercury vacuum equals 1.13 ft. water.)

Example: Find the total head required for a pump to operate under the following conditions:

Capacity 40 gal. per min. to be discharged at a pressure of 15 lb. per sq. in. at a point 30 ft. above the pump.

FIG. 71. 2-in. pump—full dia. 10-in.—variable speed.



Baash-Ross News

HOUSTON · NEW YORK

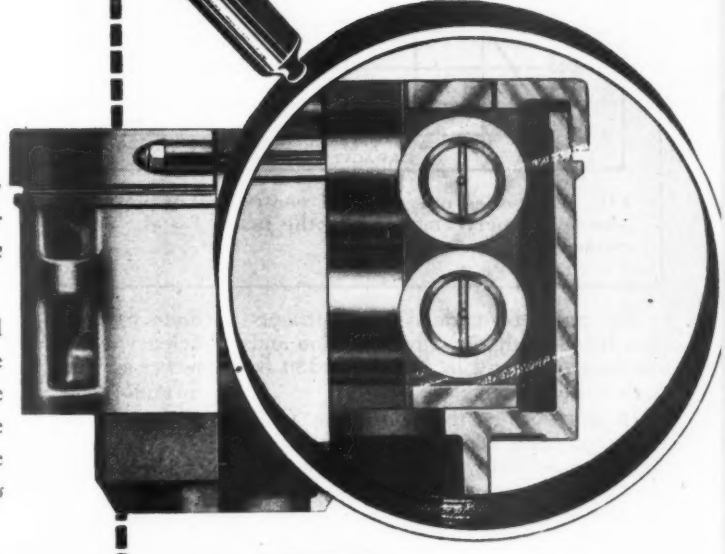
OUR 25th YEAR

What happens WHEN A KELLY DRIVE BUSHING Drives?

Did you ever stop to think that your kelly bushing serves two basic purposes on your drilling rig . . . *and that these two objectives are in direct opposition to one another?*

The kelly bushing (1) drives or rotates the drill string, and (2) permits the drill string to feed through the table while being rotated. Yet the harder the bushing pushes against the string to drive it, the more friction is set up and the more difficult it becomes for the kelly to feed freely *through* the bushing . . . *unless some means is provided of reducing this friction.*

Make the experiment outlined below and you'll see why. . .



The BAASH-ROSS Roller Kelly Bushing

means smoother bit control, greater drilling efficiency

Try this simple test: Place your hand flat on a smooth surface and push it away from you. Then press harder and push . . . and harder still and push again. Note how quickly increased pressure builds up friction between your hand and the surface until it soon becomes very difficult to move your hand smoothly over the surface. Instead, it tends to move in sudden jerks.

That's exactly what happens in the conventional flat-surfaced kelly bushing. When the string is rotating idly with no load, the kelly feeds easily through just as your hand moves smoothly when there is no pressure. But as the bushing drives the kelly faster and faster, driving pressure between bushing and kelly surfaces rapidly pyramids until smooth kelly feed is no longer possible. It becomes jumpy and erratic, which throws sudden torsional strains into the drill string, increasing the risk of twist-offs . . . puts destructive surging loads on table and swivel bearings . . . shortens the footage you get from your drilling bits . and substantially reduces the life of other rig equipment.

What's the solution? Going back to the hand test, try this: Put two ordinary round lead pencils between your hand and the flat surface and try the same experiment over again. Notice that—*no matter how hard you press down*—the two pencils eliminate friction to such an extent that your hand always moves freely and effortlessly.

And that's exactly how the Baash-Ross Roller Kelly Bushing increases drilling efficiency! By using *rollers* instead of flat drive surfaces between kelly and bushing, the Roller Kelly Bushing permits free effortless kelly feed at all times regardless of the driving pressure of rotating the string. Bit feed becomes smooth and controlled at all table speeds!

What this all adds up to . . . Because it uses *rollers* instead of flat sliding surfaces, the Baash-Ross Roller Kelly Bushing provides an accuracy of bit control *unobtainable with any other type of bushing.* This smooth accurate feed greatly increases bit footage . . . reduces strain on the drill string . . . lengthens equipment life . . . and insures greater all-around drilling efficiency wtih less equipment maintenance.

It means **Straighter Hole** because the weight is under instant, accurate control at all times. It means **Far Better Coring** because the smooth steady feed minimizes premature dulling of core bits, break-up of cores, and jamming of barrels. It means **Fewer Fishing Jobs** because the sudden torsional strains that damage drill string connections are minimized. And it means **Less Bushing Maintenance** because, in contrast to conventional kelly bushings, maintenance of Baash-Ross Roller Bushing is unusually simple—just periodic lubrication through easily-reached grease nipples.

Baash-Ross Roller Kelly Bushings are available in sizes to fit all square kellys 2½" to 6" all hex kellys 3" to 7". See your nearest Baash-Ross representative for complete details, refer to page 256 of your Composite Catalog, or write direct.

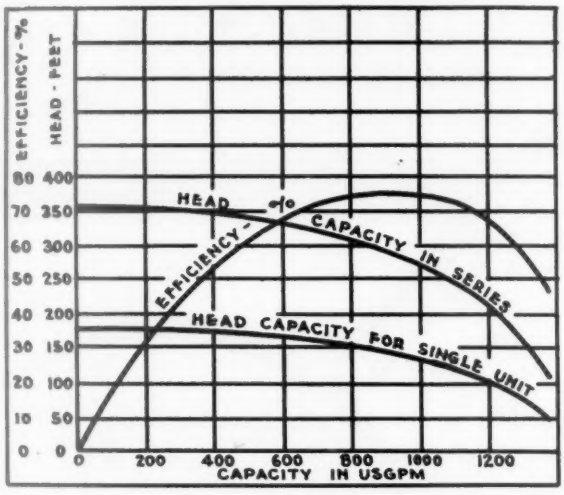


FIG. 72. Series operation of centrifugal pumps. To plot series performance add the heads for the same capacities of each pump.

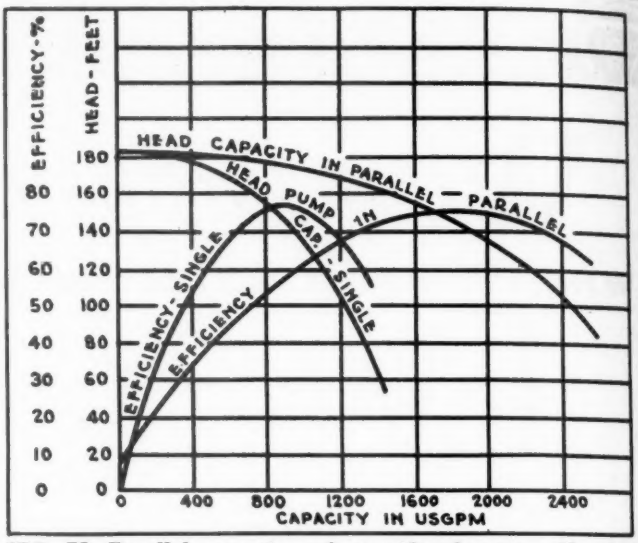


FIG. 73. Parallel operation of centrifugal pumps. To plot parallel performance add the capacities of each unit for the same head.

The pump is operated on a 5-ft. suction lift; the piping in both suction and discharge line is 2 in. and totals 150 ft. with 6 elbows.

In addition to the above the total dynamic head contains velocity head, but as the velocity head is usually (except in large capacity pumps) unimportant to the user it has been omitted.

Solution:

30 ft. (discharge head) plus 5 ft. (suction lift) equals 35 ft.

15 lb. $\times$ 2.31 (discharge pressure) = 34.6 ft.

Six 2-in. elbows are equivalent to 48 ft. of pipe.

150 ft. + 48 ft. = the equivalent of 198 ft. of pipe.

Total friction, 1.98 $\times$ 6.6 (friction loss per 100 ft. of pipe from friction table) = 13.1 ft.

Total head required is 82.7 ft., the sum of the above.

In most cases the horsepower required to pump any given quantity of water can be taken directly from tables, but there are occasions when an exact horsepower is required for an intermediate capacity. In this case, if the efficiency of the pump is known the horsepower may be figured from the following formula:

$$\text{Hp.} = \frac{\text{GPM} \times \text{feet head}}{3960 \times \text{pump eff., per cent}}$$

The derivation of this formula is as follows:

A gallon of water weighs 8.3 lb. at ordinary temperatures.

A horsepower equals 33,000 ft.-lb. per min.

It is obvious then that if a gallon of water is raised 1 ft. that 8.3 ft-lb. of work have been done. The horsepower to pump any quantity of water is then:

$$\text{Hp.} = \frac{\text{GPM} \times 8.3 \text{ lb.} \times \text{feet head}}{33{,}000}$$

There are always losses in the pump due to mechanical and disk frictions, shock, etc., so that the above horsepower as obtained for a perfect pump must be divided by the pump efficiency. The equation then becomes:

$$\text{Hp.} = \frac{\text{GPM} \times \text{feet head}}{3960 \times \text{pump eff., per cent}}$$

A piping system should always be designed with piping as large as practical, so that friction loss will be a minimum. Of course, the larger the pipe the more expensive the system becomes, so that it is necessary to consider the differences in annual power cost when pumping into pipe lines of various sizes. A saving of only 5 hp. with 2-cent power amounts to $700 per year on a 24-hour-per-day operating basis.

When a piping system is designed for a fixed quantity of water without provision for future increase or decrease, it is unnecessary to determine more than one point in order to make a good system and pump selection.

In the majority of larger jobs where there are seasonal fluctuations in water demand it is desirable to plot system curves for various sizes of pipe. These curves are then imposed on the pump curves and the horsepower for any given condition is quickly and accurately determined. Suppose we have a piping system 1000 ft. long through which it is desired to handle a flow of 400 to 1200 gal. per min. The static head is 40 ft. and it is desired to consider the total pumping head through this system.

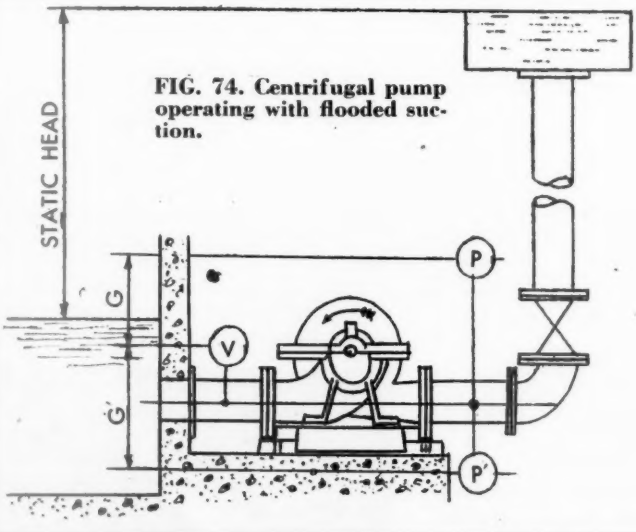


FIG. 74. Centrifugal pump operating with flooded suction.

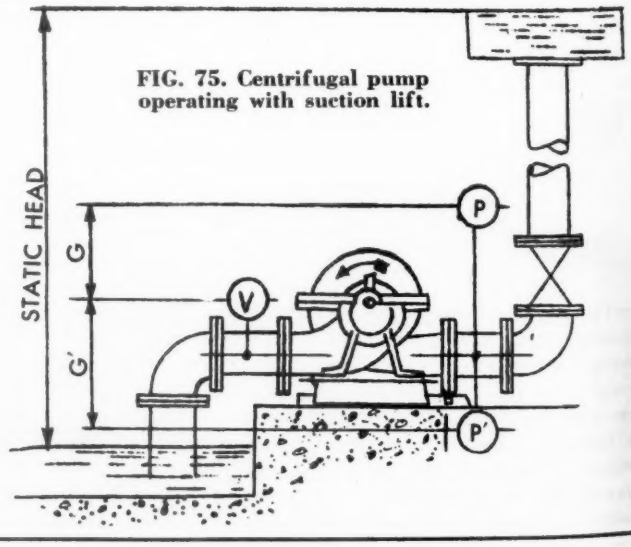


FIG. 75. Centrifugal pump operating with suction lift.

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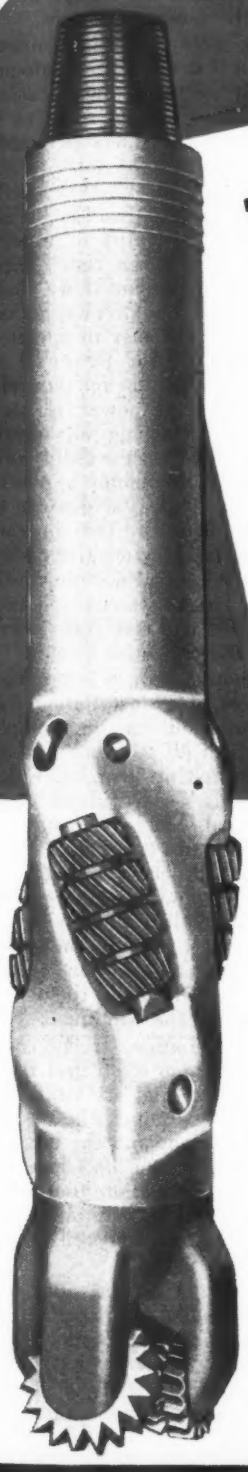

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The first step is to tabulate the friction through the pipe line for various gallon flows. This is done as follows:

TABLE 4. Frictional head loss in 1000 ft.

GPM	10-in. pipe	8-in. pipe	6-in. pipe
500	2.8	8.2	33
750	5.9	17.4	70
1000	10.1	30.2	120.4
1200	14.6	41.5	166.9
1500	20.9	62.7	253.0
2000	36.5	107.1	

If there were no static head, the curve for the pipe system would start from zero head. As the static head is 40 ft. in this example, however, the head for zero flow is 40 ft. and the head is the above pipe friction plus 40 ft. for every other quantity. Fig. 76 shows the plot of this system.

A more complicated system with elbows, gate valves, etc., is plotted in the same manner. These system curves can now be imposed on the pump curves, the operating point being the intersection of the system curve and the pump head capacity curve.

When the liquid pumped has a specific gravity other than water, multiply the pump brake horsepower for water by the specific gravity of the liquid to be handled. For instance, brine may have a specific gravity of 1.2. Water horsepower therefore, should be multiplied by this figure in determining the motor size.

Pump drive. There are several ways of driving centrifugal pumps. The best way is to direct-couple the pump to an electric motor. Another very good way is to build the pump directly on the motor. A third way is to use a V-belt drive with an electric motor to obtain a specific speed for the pump. The fourth way is to direct-couple the pump to an engine of the required speed. The fifth way is to V-belt the pump to an engine of slow speed. There are other methods that will not be discussed here.

The majority of centrifugal pumps are driven by electric motors, although steam turbines, gasoline and oil engines, steam engines, belts, etc., also are used.

Generally the most desirable arrangement is to mount the pump and driving unit on the same base with a flexible coupling between them. This coupling protects the pump and motor bearings from wear in case of unavoidable misalignment.

Alternating current may be one, two, or three phase. Installations having only a small lighting load, such as residences, are usually single phase. The majority of installations using a combination of lighting and three or more horsepower loads are three phase.

In ordering electrical equipment for alternating current it is necessary to specify the number of phases and the frequency of current alternation. Most American cities have an alternating frequency of 60 cycles per sec., although 50 cycle is used in certain localities, and 25 cycle in older water power districts.

Squirrel cage motors are the simplest and most dependable electric motors. They are ideally suited for centrifugal pump drive. They have no brushes or other moving electrical contacts. Most of the larger power companies permit them to be started directly across the line up to 40 hp. Above 40 hp. they sometimes require starters with reduced voltage windings. If this is the only equipment on the transformer bank, the power company may allow motors as large as 150 hp. to operate on a float switch.

Slip ring or wound rotor motors are similar to squirrel cage motors except that they have brushes riding on rings on the motor that may be connected to outside resistances to reduce the running speed or reduce the current inrush when starting.

Slip ring motors are much more expensive than squirrel cage motors. They are very dependable, but their higher cost prevents their use except where required by the power company.

Slip ring motors are also sometimes used when it is desired to operate pumps continuously on loads that occasionally may drop below normal so as to make a slight reduction in speed desirable.

Electric drives have some very distinct advantages over other methods. The speed of the pump and motor is constant. A known quantity of water will be handled in a given time. There is comparatively little shut down time because of repairs to an electric motor. Electric motors are easy to operate and to maintain. Cost for power in some areas compete with that for natural gas. Nearly all electric power is cheaper than gasoline. The big advantage in using electric power is the ability to start and stop an electric motor by means of a float switch. This is a distinct labor saving device. This ability to operate on a float switch also materially decreases the required size of the collection pit. As the gathering pit actually acts as a surge tank, this will materially decrease the cost of the collection center.

Electric motors have a low initial installation cost. The installation for an electric motor and starting equipment is usually about 60 per cent that of an internal-combustion engine. Electric motors for this service should be the totally enclosed, fan cooled, ball bearing type. Salt water spray in all splash-proof motors will condense on the windings. When the motor is shut down these chlorides, especially calcium chloride, will tend to collect moisture on the windings. Then when the motor is started up, it burns up because of the action of the salt water on the windings.

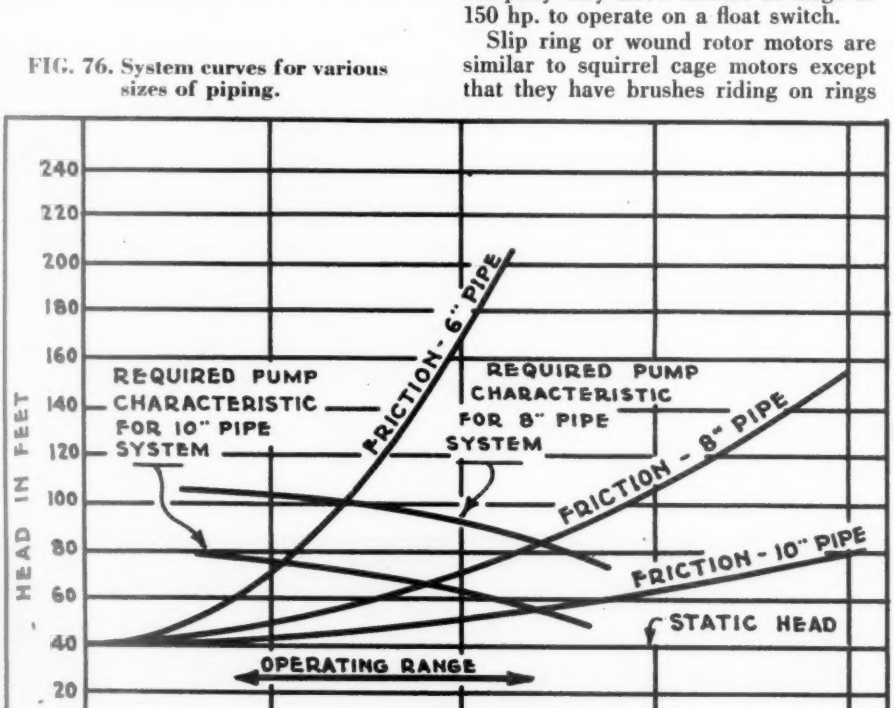
Electrical insulation, traffic cop for errant electrons, too often gets little of the consideration that its vital importance demands. Although the design of electrical equipment and the quality of its materials determine its efficiency, it is the state of insulation that decides an electrical machine's reliability. Destroy the insulation and you ruin the equipment.

Insulation is not invulnerable. Every type is surrounded by enemies, some of whose destructive work may be unsuspected until, at an instant of high voltage stress, electrical failure occurs.

Let us get acquainted with each of these trouble-makers—see how they operate and how they can be held in check. Although the motor maintenance point of view will be taken in this discussion, much of what is said will apply just as truly to the insulation in transformers or any type of electrical equipment.

One of the most dangerous enemies of electrical insulation is heat. The type of insulation found in almost all general purpose motors, Class A, is made of varnish-coated organic materials such

FIG. 76. System curves for various sizes of piping.



as paper, cotton, or silk, which become brittle and char at elevated temperatures.

Even the so-called inorganic insulators in Class B often depend on an organic component. Without organic varnish, for instance, glass tape is like a screen through which conducting materials may pass. Mica insulation is held together with a paper or cloth backing. Sealing varnish gives to water-hungry asbestos its dielectric strength.

So although Class B insulation will withstand considerably higher temperatures than Class A, the amount of heating should be kept at a minimum in electrical equipment insulated with either type of material.

Losses, which manifest themselves as heat, increase with overloading. Overloading is never to be recommended except as an emergency measure. Harmless in brief spurts of a moment or two, overloading shortens insulation life measurably over prolonged periods of time.

Another cause of heating is poor ventilation. When air vents become clogged, the heat of machine operation is imprisoned in a motor, sometimes building up to dangerous temperatures. Open-type motors in particular need cleaning at frequent intervals.

Of course terminal voltage must be maintained at machine requirement if overheating is to be avoided. Undervoltage, which causes a motor to draw too much current from the line, may be just as dangerous as overvoltage. Changing transformer taps is one way of correcting either condition. Installing a load center power distribution system is another.

High voltage as an insulation enemy inflicts damage immediately and drastically. It breaks down insulation, just as water at high pressure breaks through pipe. It destroys any type of electrical insulator.

Accidental connection of a motor to a line of wrong voltage sometimes occurs. More frequently, instantaneous high voltage is caused by lighting or switching surges. A permanent overvoltage condition can be uncovered by a voltmeter check.

Water can reduce the insulating value of any material considerably. Water has a great capacity for absorbing mineral salts to form solutions that are excellent conductors of electricity.

Although insulating varnish is water-repellent, tiny cracks developed in this protective covering may be sufficient to admit undesirable moisture.

Water should be excluded from motors as much as possible. For some locations a drip-proof or totally enclosed motor is recommended. Even this type of motor may admit water, however, unless joints in motor frame and brackets are kept tight.

When a megger test shows that pressure of water has dangerously lowered the dielectric strength of insulation, the motor should be thoroughly dried out by a suitable method.

The time to get rid of moisture in electrical equipment is immediately!

TABLE 5. Electric power costs.

Hp.	Electric motor cost per hour based on 100 per cent a-c. power factor and 85 per cent motor efficiency when the current rate per kw-hr. is:									
	¾ cent	1 cent	1½ cents	2 cents	2½ cents	3 cents	3½ cents	4 cents	4½ cents	5 cents
5	0.03	0.04	0.06	0.08	0.10	0.13	0.15	0.16	0.19	0.20
10	0.06	0.08	0.13	0.16	0.21	0.26	0.30	0.32	0.39	0.42
15	0.09	0.13	0.19	0.26	0.33	0.39	0.46	0.52	0.59	0.66
20	0.13	0.17	0.26	0.34	0.44	0.52	0.61	0.68	0.79	0.88
25	0.16	0.22	0.33	0.44	0.54	0.66	0.76	0.88	0.99	1.08
30	0.20	0.26	0.39	0.52	0.65	0.79	0.92	1.04	1.19	1.30
35	0.23	0.30	0.46	0.61	0.76	0.92	1.07	1.22	1.38	1.52
40	0.26	0.34	0.52	0.69	0.87	1.05	1.22	1.38	1.58	1.74
45	0.29	0.40	0.59	0.79	0.99	1.18	1.38	1.58	1.78	1.98
50	0.32	0.43	0.65	0.87	1.10	1.31	1.53	1.74	1.96	2.20
60	0.39	0.52	0.79	1.05	1.32	1.58	1.84	2.10	2.36	2.64
70	0.46	0.61	0.92	1.22	1.53	1.84	2.15	2.44	2.76	3.06
80	0.52	0.70	1.05	1.40	1.75	2.10	2.46	2.80	3.15	3.50
90	0.59	0.79	1.18	1.58	1.98	2.37	2.76	3.16	3.55	3.96
100	0.65	0.87	1.31	1.75	2.19	2.63	3.07	3.50	3.96	4.38
120	0.78	1.05	1.57	2.10	2.63	3.15	3.68	4.20	4.74	5.26
140	0.92	1.23	1.84	2.46	3.07	3.68	4.30	4.92	5.52	6.14
150	0.98	1.31	1.97	2.63	3.30	3.95	4.61	5.26	5.94	6.60
160	1.04	1.40	2.10	2.80	3.50	4.20	4.92	5.60	6.30	7.00
175	1.14	1.53	2.30	3.07	3.84	4.61	5.37	6.14	6.93	7.68
180	1.18	1.58	2.36	3.16	3.96	4.74	5.52	6.32	7.10	7.92
200	1.30	1.74	2.62	3.50	4.38	5.26	6.14	7.00	7.92	8.76
225	1.46	1.96	2.95	3.94	4.92	5.92	6.90	7.88	8.91	9.84
250	1.62	2.17	3.27	4.37	5.48	6.57	7.67	8.74	9.88	10.96
275	1.78	2.39	3.60	4.81	6.02	7.23	8.43	9.62	10.87	12.04
300	1.96	2.62	3.94	5.26	6.60	7.90	9.22	10.52	11.84	13.20

TABLE 6. Gasoline engine power costs.

Hp.	Gasoline engine operating cost per hour when gasoline cost per gallon is:					
5	0.06	0.07	0.08	0.09	0.10	0.11
10	0.12	0.15	0.17	0.19	0.21	0.23
15	0.17	0.22	0.25	0.28	0.31	0.34
20	0.23	0.29	0.34	0.38	0.42	0.46
25	0.29	0.36	0.42	0.47	0.52	0.57
30	0.35	0.44	0.50	0.57	0.63	0.69
40	0.47	0.58	0.67	0.76	0.85	0.94
50	0.59	0.72	0.84	0.95	1.06	1.17
60	0.70	0.87	1.01	1.14	1.27	1.40
70	0.82	1.02	1.17	1.33	1.48	1.63
80	0.93	1.15	1.33	1.50	1.68	1.86
90	1.05	1.20	1.49	1.69	1.89	2.09
100	1.16	1.43	1.66	1.88	2.10	2.32
120	1.39	1.72	1.99	2.26	2.52	2.78
140	1.63	2.01	2.32	2.63	2.94	3.25
150	1.74	2.15	2.48	2.81	3.15	3.48
160	1.86	2.30	2.66	3.00	3.36	3.72
175	2.03	2.50	2.90	3.28	3.67	4.05
200	2.32	2.86	3.32	3.76	4.20	4.64
225	2.61	3.22	3.74	4.23	4.72	5.21
250	2.90	3.58	4.16	4.71	5.26	5.81
275	3.19	3.93	4.58	5.18	5.78	6.38
300	3.48	4.30	4.96	5.62	6.30	6.96

Gasoline cost is based on consumption of 0.7 lb. or 0.112 gal. per b. hp.-hr. and 0.1 cent per b. hp.-hr. for lubricating oil and the engine operating at continuous full load.

TABLE 7. Natural gas power costs per hour of operation.

Hp.	Natural gas cost per 1000 cu. ft.								
	4 cents	6 cents	8 cents	10 cents	12 cents	14 cents	16 cents	18 cents	20 cents
5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
10	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04
15	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05
20	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07
25	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.09
30	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11
35	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13
40	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14
45	0.07	0.08	0.09	0.10	0.12	0.13	0.14	0.15	0.16
50	0.08	0.09	0.10	0.12	0.13	0.14	0.15	0.17	0.18
55	0.08	0.10	0.11	0.13	0.14	0.16	0.17	0.18	0.20
60	0.09	0.11	0.12	0.14	0.15	0.17	0.19	0.20	0.22
65	0.10	0.12	0.13	0.15	0.17	0.18	0.20	0.22	0.23
70	0.11	0.12	0.14	0.16	0.18	0.20	0.22	0.23	0.25
75	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.25	0.27
80	0.12	0.14	0.16	0.18	0.21	0.23	0.25	0.27	0.29
85	0.13	0.15	0.17	0.20	0.22	0.24	0.26	0.28	0.31
90	0.14	0.16	0.18	0.21	0.23	0.25	0.28	0.30	0.32
95	0.14	0.17	0.19	0.22	0.24	0.27	0.29	0.32	0.34
100	0.15	0.18	0.20	0.23	0.26	0.28	0.31	0.33	0.36
105	0.16	0.19	0.21	0.24	0.27	0.30	0.32	0.35	0.38
110	0.17	0.20	0.22	0.25	0.28	0.31	0.34	0.37	0.40
115	0.18	0.20	0.23	0.26	0.29	0.32	0.35	0.38	0.41
120	0.18	0.21	0.25	0.28	0.31	0.34	0.37	0.40	0.43
125	0.19	0.22	0.26	0.29	0.32	0.35	0.39	0.42	0.45
130	0.20	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47
135	0.21	0.24	0.28	0.31	0.35	0.38	0.42	0.45	0.49
140	0.21	0.25	0.29	0.32	0.36	0.39	0.43	0.47	0.50
145	0.22	0.26	0.30	0.33	0.37	0.41	0.45	0.48	0.52
150	0.23	0.27	0.31	0.35	0.38	0.42	0.46	0.50	0.54

Natural gas cost is based on a consumption of 13 cu. ft. per b. hp-hr. and 0.1 cent per b. hp-hr. for lubricating oil, and the engine operating at a continuous full load (1200 B.t.u. gas.)

No insulation is proof against chemical deterioration, although some types of insulating material and varnish are more resistant than others. Where motors will operate in a corrosive atmosphere, the advice of the manufacturer is helpful in selecting the best type of insulation.

Totally-enclosed motors may be required, or chemical fumes can be excluded by introducing a clean source of ventilating air from the outside.

Air-borne powdered chemicals in the motor act in the same way as any dust, to clog air ducts and windings and cause overheating. As these chemicals rarely occur in a perfectly dry state, they may be highly corrosive. Scheduled cleaning is particularly important when motors operate near a chemical process.

Oil works its way through varnish by a softening-up process. Not only does it attack the varnish, but it washes dirt and other conducting materials into existing cracks and pores. Combining with dirt, it gums up the machine, filling ventilating spaces and causing overheating. Oil is particularly injurious to the mica insulating bars in a d-c. motor.

To prevent oil from escaping into parts of the motor where it not only does no good, but endangers the insulation, check oil seals, well covers, and plugs at regular intervals. Never lubricate sleeve bearings equipped with oil rings while the motor is running as oil runs above the level of the ring and sprays into the motor, carried by air currents. In an oily atmosphere, a clean source of ventilating air should be introduced from the outside.

Gum can be removed from the inside of a motor with a solvent, such as carbon tetrachloride and gasoline in equal parts, applied with a rag. A motor should not be flooded with solvent. After the cleaning treatment, windings should be dried and a new layer of insulating varnish applied.

Unless electrical insulation is carefully handled, it may be injured by bending, bruising, scratching, or breaking. There are things you cannot do to insulation and expect it to stand up.

The list of things to avoid if insulation is to be kept intact sounds almost too obvious to mention: Don't hit windings with a hammer or run any sharp instrument such as a knife into insulation; don't roll an armature on the floor, or put a sling around the coils of an armature; don't direct excessive air pressure against the windings. No matter how elementary this advice may seem, any insulation engineer can testify that these commandments are violated daily.

Dirt is principally dangerous because it clogs windings, causing overheating. Also, it may absorb water from the atmosphere to form corrosive compounds. Abrasive dust and dirt erode insulation.

To fight dirt, wipe off motor on regular inspections. Blow dust out of the wound section at necessary intervals with a pressure of not more than 40 lb. of dry compressed air, or else remove dust with the suction method. Open-type motors, of course, need most frequent cleaning, and the best schedule for cleaning any motor depends on the cleanliness of the atmosphere.

Keep a motor clear of metal dust or cuttings that can be drawn into the windings to damage the insulation.

When cleaning a motor, cotton waste should not be used, for it leaves thread and lint that will provide new surfaces for collecting dirt.

Remember, insulation can deteriorate rapidly, or it can last for years—depending entirely on the protection it is given against its natural enemies.

Gas and gasoline engine drives are very satisfactory. These units are usually noisy. Engine drives have the advantage of being able to slow up the pump to compensate for a decrease in the amount of water to be handled. An electric motor unit can only throttle to the amount of water desired by pinching on the discharge valve. A gas engine as a rule will be cheapest to operate, provided the unit is well built and has enough reserve horsepower built into it.

The three tables on the preceding page will aid in the selection of the drives. The figures for electric power are actual. The figures for gas and gasoline must have about one-half reserve horsepower added to the horsepower required before figuring the cost.

The selection of a centrifugal pump to handle salt water must be carefully chosen. The procedure should be as follows: The amount of water to be handled must be carefully estimated. Usually Railroad Commission data will give only an approximate idea as to the amount of water that is being produced. This is usually caused by a delay in obtaining and compiling the Railroad Commission data. Wherever possible, a meter reading should be taken.

The next step is to calculate pipe friction. The length of the line and its size is important. The type of pipe will also determine the coefficient of friction for that particular type of piping. Care should be taken to consider the difference in elevation between pumping points. If meters, ells, tees, and other friction-raising conductors are placed in the line, their friction loss should also be known.

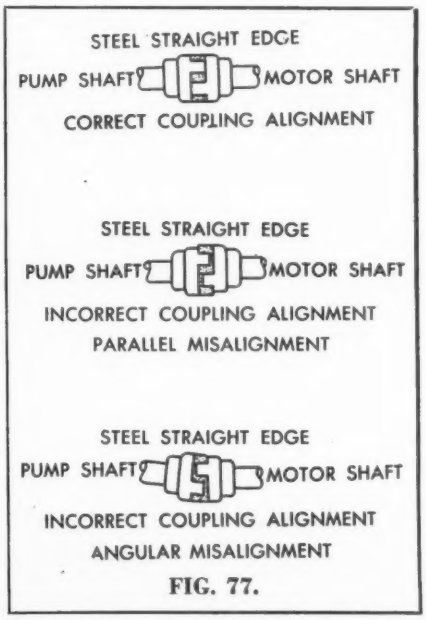


FIG. 77.

This information can then be boiled down to two things: Gallons per minute and total dynamic head. The manufacturer's pump curves can usually be depended on. Therefore, select a pump that will have the head and volume just about the midpoint of the recommended curve. The efficiency of the pump will always be highest in this area. The drive should then be selected with enough horsepower to protect itself if the pump should be operated at some future time against a low discharge head.

In selecting a location for the centrifugal pumping unit the following factors must be considered:

The pumps should be as near the water supply as practical, so that the static suction lift will be low and so that a short direct suction pipe may be used. If at all possible, the pump should be placed so that a flooded suction can be obtained. To minimize head loss from friction, the pump should be situated so that a short direct suction pipe with the least number of elbows and fittings may be used. The pump should be placed so that it will be accessible for inspection during operation. Head room should be provided when it is necessary to use cranes. The pump should be protected against floods and motor driven units must be installed in a dry place.

The foundation should be sufficiently substantial to absorb any vibration and to form a permanent, rigid support for the base plate. This is important in maintaining the alignment of a direct connected unit. An adequate concrete foundation is highly desirable. Foundation bolts of the proper size should be embedded in the concrete.

Any base plate, no matter how heavily it is built, may be slightly sprung in shipment, or may be distorted by an uneven support on the foundation, or by uneven tightening of the foundation bolts, or by the pull from the pipe connections. So it is necessary to be careful when installing the pump to obtain perfect alignment of the coupling. A flexible coupling will not compensate for misalignment. Inaccurate alignment of the coupling results in rapid wear of the coupling bushings, heating of the bearings, and loss of efficiency. Therefore, after the pump is fastened on the foundation, it is necessary to see that the shaft of the pump and of the driving machine are in line. Before the couplings are installed, the pump should be completely connected to its piping and the base plate leveled and adjusted to position by shims and wedges, so as to bring the two halves of the coupling into perfect alignment. To facilitate checking the alignment a steel straight edge should be used. Couplings must line to within 0.005 in. otherwise as much as one-half the horsepower at the drive will be consumed in the coupling. Excessive wear will also occur to the coupling.

★★★

(The final installment, No. 12, will be published in an early issue.)

Standard Packing of the Industry

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FIRST U. S. GAS TURBINE DEMONSTRATED

By **JOHN H. KUNKEL**
Refinery Editor

EXCLUSIVE THE much discussed gas turbine, which as a prime mover falls into the class of the diesel engine with respect to fuel consumption, and approaches the steam turbine in reliability and maintenance, is no longer in the realm of things to come.

The first large gas turbine ever built in the United States for continuous, long-run service, and also said to be the world's first gas turbine for ship propulsion was recently demonstrated.[1] The unit was designed and built in cooperation with the U. S. Navy Bureau of Ships and is the first of several marine gas turbines to be built for the Navy after the parent unit is tested at sea.

The marine unit demonstrated burned No. 2 distillate, and developed 2500 useful horsepower. It has an overall efficiency of about 29 per cent. The theoretical efficiency of a plant consisting of its combination of elements is 32.5 per cent.

The weight of the marine gas turbine demonstrated is approximately 30 lb. per hp., and it occupies a space of about 3.5 cu. ft. per hp. Further development is expected to lead to a substantial reduction in weight and space per horsepower.

Officials stated that gas-turbine plants with power output of 10,000-15,000 hp. are possible, and, under proper incentive, may even exceed this capacity, although units within the size ranges common to the central power station field will be some time in coming.

[1]Demonstration took place on July 25 at the Elliott Company plant, Jeannette, Pa.

● **Fuels.** The marine unit demonstrated is designed to burn high-grade fuel oil. Fuel consumption of the unit is 47 lb. per hp-hr. The burning of coal will always be an important consideration, and the field of the gas turbine will be vastly extended when this possibility is realized, according to Elliott engineers. Many approaches to the practical solution of this problem are under way. Whether the ultimate solution will be direct burning of pulverized coal, burning of gas from coal, or burning oil from coal, is a matter for the future to determine.

As a prime mover, the gas turbine heralds a new chapter in the history of power plants. It will eventually find its proper place in power generation and probably one that no other type of prime mover occupies at the present time.

● **Elements of the marine gas turbine and their combination.** The basic elements of a gas turbine are: A single combustion chamber, a single compressor, and a single turbine. These basic elements may be increased in number, as shown in Fig. 1, and to them may be added a regenerator, and one or more intercoolers. Thus, a gas turbine is a composite of machine, combustion, and heat transfer elements that may be arranged in a great variety of combinations.

The units, and their combination, in the marine gas turbine under discussion, are those shown in the fourth column of Fig. 1, and, in that combination, the theoretical efficiency of the turbine is 32.5 per cent. The units are: A high-pressure combustion chamber, a low-pressure combustion chamber, a high-pressure compressor, a low-pressure compressor, a high-pressure turbine, a low-pressure turbine, a regenerator, and an intercooler.

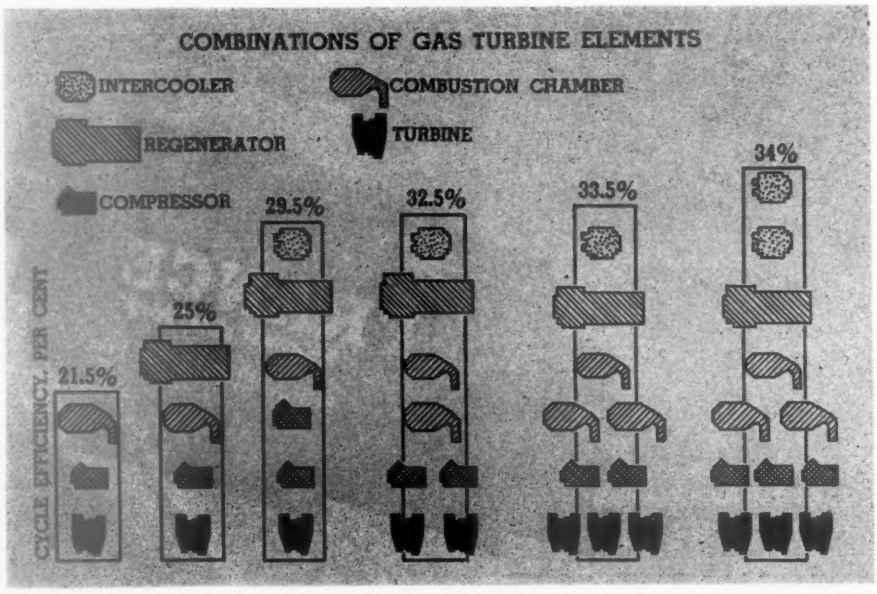
The turbine discussed here is of interest to oil and gas men both because of the type of fuel used and its wide potential application.

Reference to Fig. 1 shows that a combination of the basic elements, i.e., a combustion chamber, a compressor, and a turbine results in a theoretical efficiency of 21.5 per cent. When regenerator is added, the theoretical efficiency increases to 25 per cent. The addition of a second compression stage to these units increases the theoretical efficiency to 29.5 per cent. The further addition of a second combustion chamber and a second turbine increases the theoretical efficiency to 32.5 per cent. Beyond this, the addition of a third combustion chamber and a third turbine results in a theoretical efficiency of 33.5 per cent; and, in the final combination, the addition of a third compression stage and a second intercooler increases the theoretical efficiency to 34 per cent.

If Fig. 1 is viewed as a chart, the efficiency curve will rise sharply through the first 4 combinations, but through the final 2 combinations the rise will be less pronounced. It was from these considerations that Elliott engineers elected to employ the fourth combination in the gas turbine herein described.

● **Flow.** The flow of air in this unit, as shown in Fig. 2, begins at the low-pressure compressor, which takes in free air and compresses it to a pressure of 43 lb. per sq. in. abs. and a temperature of 300° F. The temperature is then lowered to about 90°F. by flow through a water-cooled intercooler to reduce the specific volume of air before its introduction into the second stage of compression, the work in that stage being dependent on the volume so obtained. In the high-pressure compressor, the pressure of the air is increased to 96 lb. per sq. in. abs., and the temperature to about 280°F. The air then passes through the regenerator where a portion of the heat in the exhaust gas is recovered before it enters

FIG.1.



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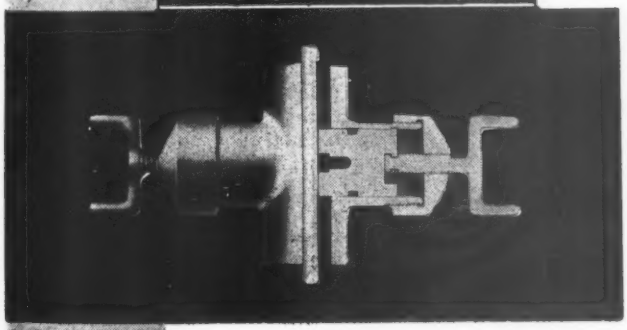

"DOUBLE E" BLOWOUT PREVENTER

The "Double E" Blowout Preventer for sucker or polished rods works on the same principle as the stripper but is constructed somewhat differently. Instead of the soft rubber packing, cylindrical steel rams are used, to which has been molded a fabric reinforced sealing element. This oil resistant synthetic rubber element backed by the steel ram prevents leakage against high pressure.

The use of the Blowout Preventer in conjunction with the Sucker Rod Stripper provides ideal protection against handling wet rods and pressure surges in heading wells.

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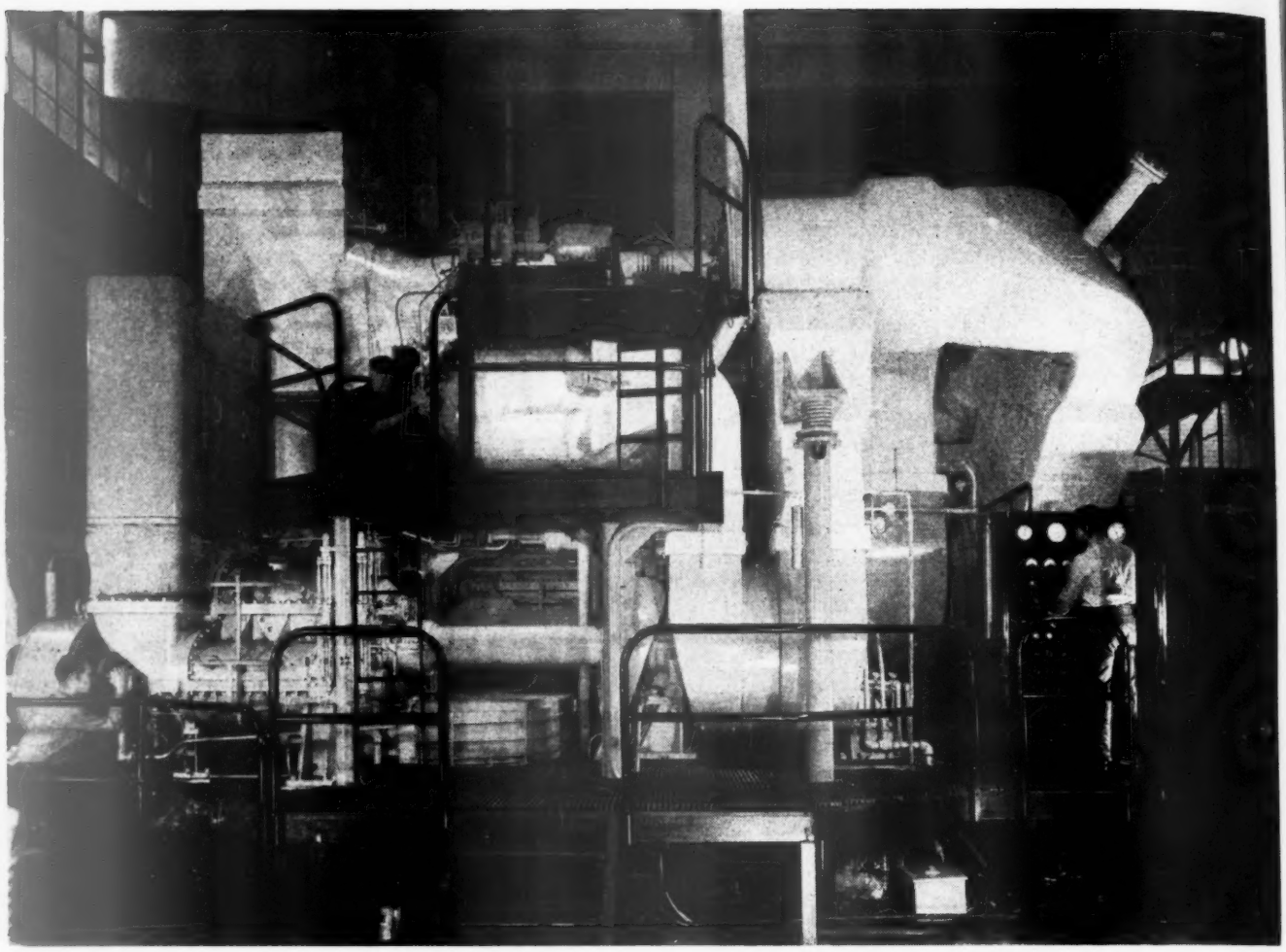

The first gas turbine for ship propulsion ever built has been successfully completed. It is also the first power gas turbine built in the United States for continuous long-time service.

the high-pressure combustion chamber.

In the high-pressure combustion chamber, "spitter" injected fuel oil is burned directly in the air stream, and a temperature of 1230°F. is reached at the entrance to the high-pressure turbine. In this turbine, the heated air is expanded to 53 lb. per sq. in. abs., and in so doing sufficient power is developed to drive the low-pressure compressor.

The air from the high-pressure turbine exhaust is then reheated in the low-pressure combustion chamber to elevate its temperature to 1207°F. before it is expanded in the low-pressure turbine. Five thousand hp. is realized from the low-pressure turbine, 2500 of which is expended in driving the high-pressure compressor. The remaining 2500 hp. is excess power, which, in the marine gas turbine, drives the propeller.

After the air leaves the low-pressure turbine, at slightly above atmospheric pressure, it passes through the regenerator, where it preheats the fresh compressed air from the high-pressure compressor. The exhaust gas passes through the stack at a temperature of 400°F. and is discharged to atmosphere.

In this flow arrangement, the 2 compressors are driven by separate turbines. This is not an essential of a plant containing 2 compressors and 2 turbines, but in this case it was desirable, for naval power plants are operated more than 90 per cent of the time at other than fuel load, and it is, therefore, important to have highly efficient part-load performance. The arrangement of machines in a gas turbine cycle, with individual drives for the compressors, makes it possible to achieve this result.

A difference between part-load and full-load economy exists. To reduce the power output it is necessary to decrease the amount of hot air passing through the turbines, or to reduce the temperature of the air. It may be necessary to do both. The best efficiencies are obtained when the temperature of the compressed air is as high as possible before being put to work in the turbines. Thus, for best economy it is desirable to operate at reduced power by decreasing the supply of compressed air rather than by reducing the gas temperature. The best approach to high-temperature, reduced-flow operation is realized because the components are so arranged that the main power turbine can always be operated at full temperature.

Complete control is obtained by regulating the fuel flow to the turbine driving the first-stage compressor. As the amount of air that enters the system is controlled by this compressor, it is apparent that this one feature can produce ease of control, and, at the same time, permit efficient operation of the main power turbine.

● **Non-useful energy.** A major requirement for the efficient production of power by a gas turbine is a means of compressing large volumes of air economically. Probably the most obvious feature of a gas turbine plant is the compressor, or compressors, and the relatively great power required for compression. This power has such an apparent parasitic nature that it is well to remember that comparable amounts of non-useful energy are dissipated by all thermodynamic machines.

In the internal-combustion engine, the power cylinder is also a compressor cylinder, and energy is removed from the crankshaft on each compression stroke. In addition, the engine exhaust carries away large amounts of low-grade head. In the steam power plant, the condenser cooling water must dissipate the heat of vaporization originally supplied in the boiler. It is an unfortunate thermodynamic fact that it is impossible to convert more than a fraction of the heat energy of fuels to useful work in any known heat engine.

In the gas turbine plant the unavailable heat appears as compressor work. As in the case of Otto cycle and diesel engines, this compression work is taken directly from the power shaft.

● **The Elliott-Lysholm compressor.** Refinery men will be interested in the new type compressor developed for this marine gas turbine, because of its potential applications in refining and natural gas-

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ELLIOTT COMPANY OFFICIALS WHO GUIDED CONSTRUCTION OF FIRST GAS TURBINE

Ronald B. Smith
Engineering Vice President

W. A. Elliott
Executive Vice President

C. R. Soderberg
Consulting Engineer

oline operations. Fig. 3 shows the internals of a 12,500 cu. ft. per min. Elliott-Lysholm compressor of which 2 are employed in the gas turbine plant. (Fig. 3 not released.)

Termed a "meat chopper" because of its likeness thereto, this compressor is a combination of the advantages of a reciprocating compressor and those of a strictly rotary machine. It is a positive displacement type unit that has only 2 moving parts of exceptionally rugged construction. The 2 cooperating rotors, which are timed by the ground gears directly mounted on their shafts, are journaled in precision automotive-type bearings specially selected to give indefinite life and reliability of operation. All parts are enclosed in an accurately machined casing, scientifically jacketed to insure symmetrical temperature distribution, producing correct alignment of parts even under the extreme conditions of operation and temperature.

While running at the high speed characteristic of turbomachinery, it inhales successive bites of air, which are enclosed, cut off, and compressed by squeezing, and finally pushed out into the exhaust system. At both the intake and exhaust, the successive bites overlap so that a continuous flow is obtained.

This is a genuine positive displacement machine that, for each turn of the shaft, takes in and compresses a fixed volume of air independent of the back-pressure imposed; that is, over a very broad range the operating pressure can be independent of air quantity. This has the practical effect of allowing selection of a flow-pressure relationship exactly suited to the associated turbines. Consequently, a gas turbine plant employing these compressors has a flexibility previously believed to be unrealizable. An important concomitant is the high efficiency of part-load operation, so desirable in marine propulsion machinery.

In 1940, the Elliott Company tested a small Lysholm compressor, invented by Alf Lysholm, a Swedish engineer of Ljungstroms Angturbin. Having become convinced of the potentialities of this method of air compression, Elliott Company embarked on full-scale development that resulted in the present compressor.

● **Heat supply for gas turbines.** The output of a gas turbine plant is determined by the difference in temperature level between the expansion of the hot air in the turbine and the compression of the air in the compressors.

With ideal, absolutely frictionless compressors and turbines, without any losses, air would be compressed in the compressor and expanded in the turbine. The turbine would merely drive the compressor, but there would be no power left for useful work. With such perfect machinery it would be found, however, that as soon as the temperature of the compressed air is raised before expanding it, useful power will be developed by the machine. This, then, would be an ideal gas turbine as a prime mover, and the more the temperature of the compressed air is raised, the more work can be obtained from a given flow.

An actual gas turbine operates in the same manner, but, inasmuch as the actual machine has losses, it is necessary to raise the temperature of the air in order to make the machine rotate without delivering any useful output. As shown in Fig. 4, the larger the losses in the machines, the higher must be the temperatures of the compressed air; that is, the more inefficient they are, the higher must be the temperature of the compressed air in order to make the machine self-sustaining.

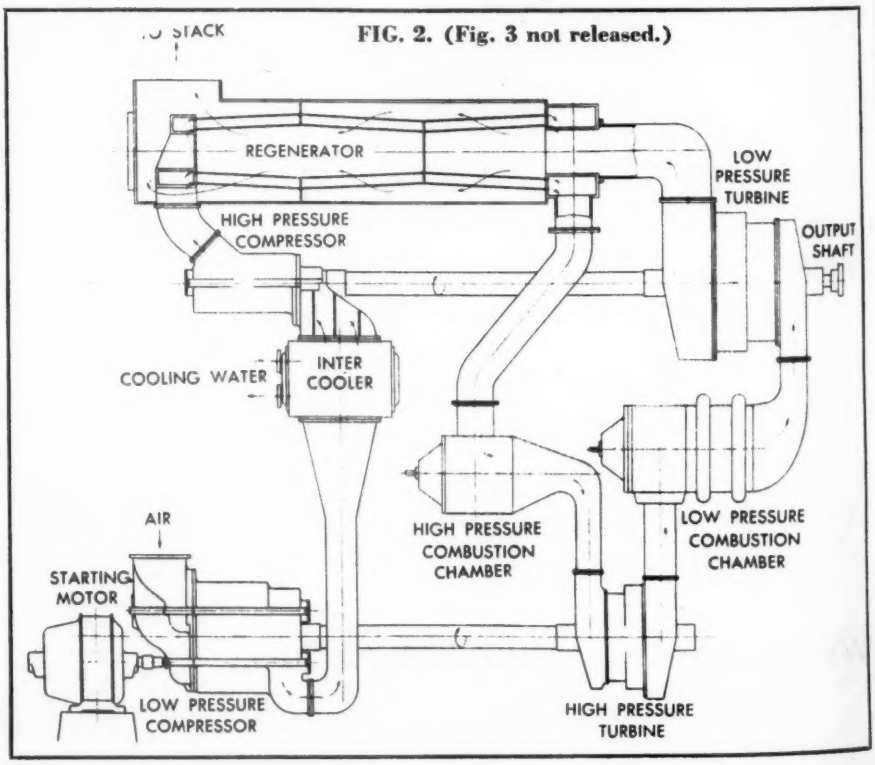
As in the case of the theoretically ideal machine, the higher the temperature of the compressed air, in the actual machine, the more work can be obtained from a given rate of air circulation, and thus the higher the efficiency of the plant. Thus, the gas turbine is operated at the very highest temperatures that the available materials can withstand with reliability. In the gas turbine the air is heated by burning fuel directly in it, and the heat liberated by combustion is immediately available in the place where it is needed.

● **The combustion chamber.** The combustion chamber is a simple right angle in a pipe line, and has no inner shell separating combustion air from cooling air. The entering air flows naturally into a double vortex, in which is accomplished the burning out of the partially burned fuel and air mixture issuing from the cast cone at the fuel inlet end. The fuel is injected at this point by a "spitter-type" injector. High temperature air is caused to flow into the cone in such a way as to maintain a steady flame, even though the fuel is injected intermittently. This combustion chamber operates at a minimum pressure drop, and can cover a wide range of load without burner replacement.

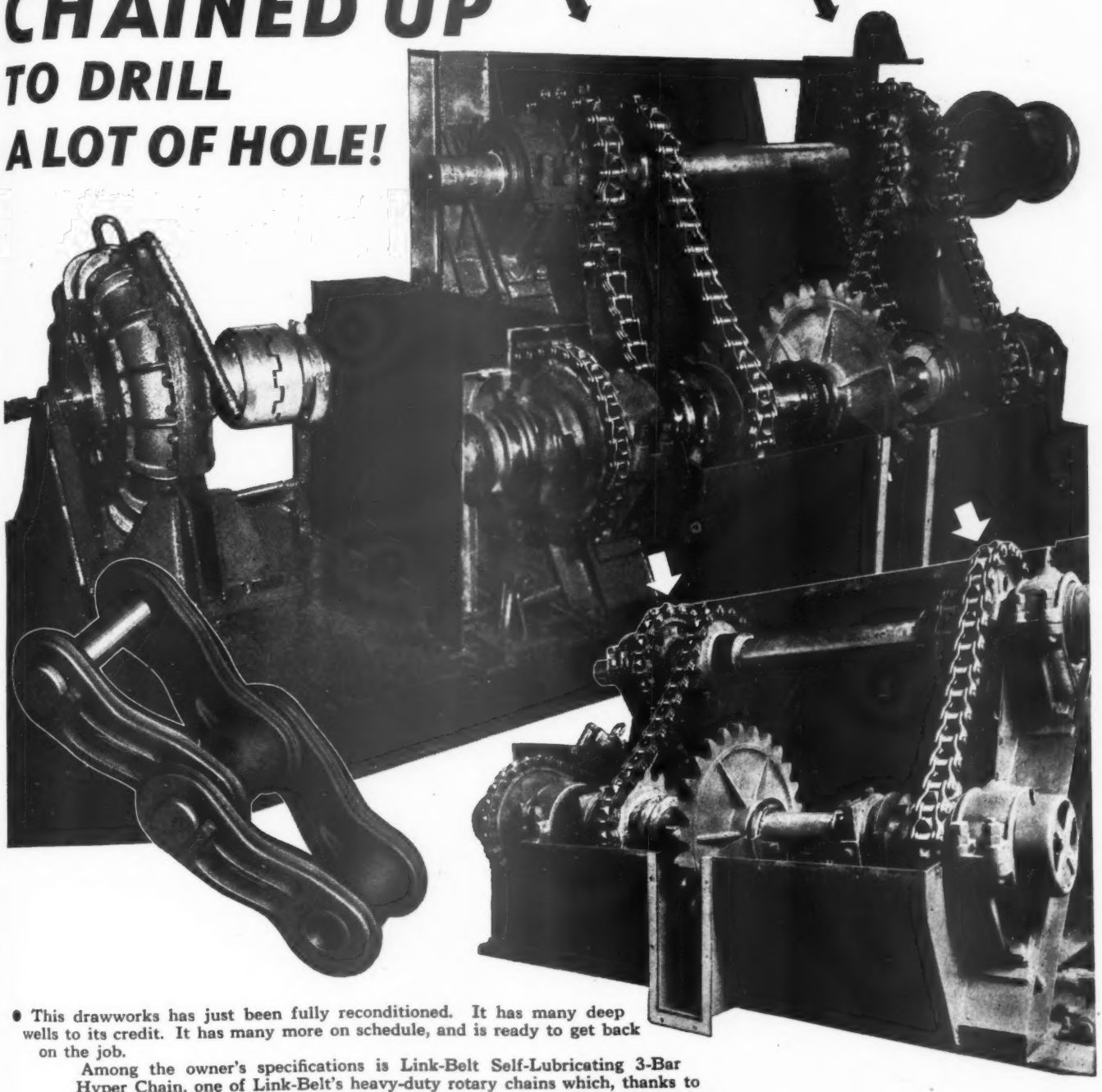
● **Preheating compressed air.** Not all the temperature rise of the compressed air need be obtained by burning fuel. Part of it is obtained by preheating the compressed air ahead of the combustion chamber in the regenerator by transfer of heat from the hot exhaust gases discharging to stack.

The design of the regenerator, or preheater, presented a problem of considerable proportions, for the use of a gaseous thermodynamic medium worked against the designer, and unless the problem was properly solved the heat transfer coefficients would be only a fraction as high as those used in boiler practice due to the fact that gas is present on both sides of the heat transfer surfaces, and without departure from the conventional the

FIG. 2. (Fig. 3 not released.)



COME WHAT MAY—THIS DRAWWORKS IS CHAINED UP TO DRILL A LOT OF HOLE!



● This drawworks has just been fully reconditioned. It has many deep wells to its credit. It has many more on schedule, and is ready to get back on the job.

Among the owner's specifications is Link-Belt Self-Lubricating 3-Bar Hyper Chain, one of Link-Belt's heavy-duty rotary chains which, thanks to unfailing performance under hardest drilling conditions, are standard drives among so many operators.

Improvements brought to the field by this dependable chain include the patented oil-grooved drop forged side bar which permits free entry of oil to joint and bearings. With this exclusive feature in design go the research, the engineering, the quality materials and the know-how workmanship that have characterized Link-Belt Chains through 70 years of continuous improvement. Yes, come what may, this drawworks is chained up to drill a lot of hole, regardless of speed, depth, or load requirements.

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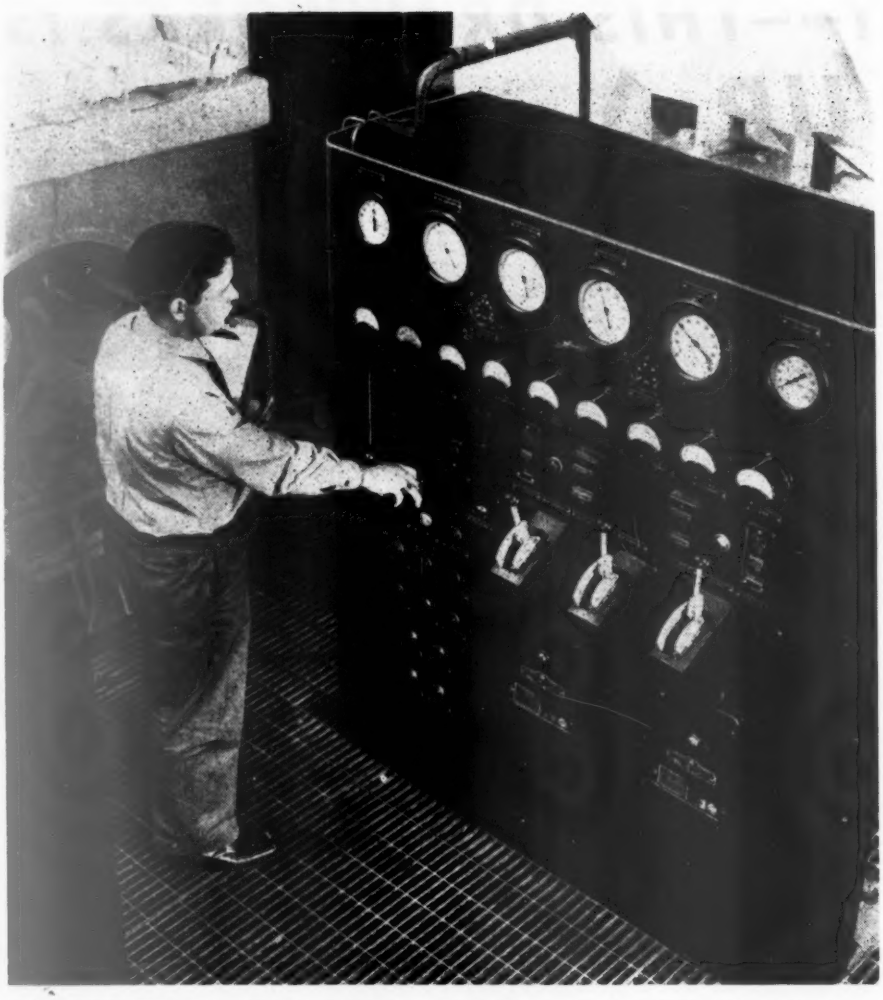
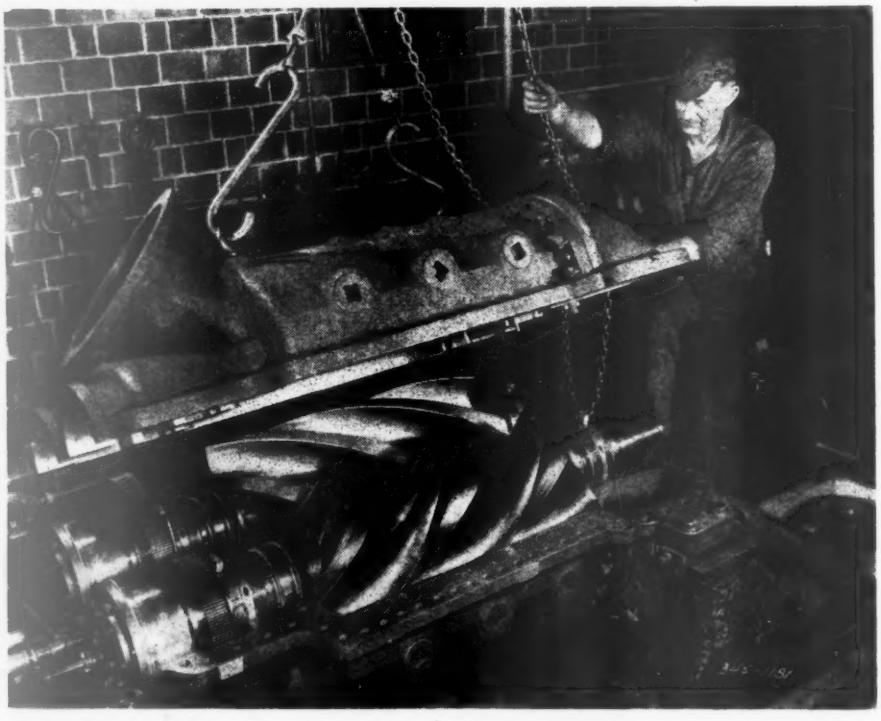


The new Elliott gas turbine plant is operated by one man stationed, as shown above, at a central control panel. Instruments tell him at a glance all he needs to know about temperatures, pressures, speeds, and the performance of all working parts. Fuel flow is controlled by airplane type hydraulic levers.



Vital to the successful operation of the new gas turbine is the 12,500 cu. ft. per min. compressor shown here with upper casing removed. Air enters the bottom of the casing at the right. The quantity of air is directly proportional to the speed of rotation and is independent of discharge pressure.

preheater would be of such tremendous size and proportions as to make its use impossible.

The design problem was further complicated by the necessity of minimizing pressure drop across the regenerator, for every pound of pressure available must be conserved for use in expanding the air through the turbine. Thus, a very real limitation is imposed on the extent to which heat transfer can be increased by increasing the velocity of flow.

The volume of the regenerator surface that must be installed for a given duty is determined by the closeness with which surface may be packed into a unit volume. Thus, if one design provides 20 sq. ft. of heating surface per cu. ft. of volume occupied, and another provides 50 sq. ft. per unit volume occupied, a regenerator made of the second type surface will occupy only two-fifths of the volume of the first. Herein lies the attractiveness of extended surface in the design of gas turbine regenerators.

Fig. 5 details the layout of tubes in the regenerator used in the gas turbine. The use of streamline tubes, and tubes nesting among one another, as shown, both decreases the pressure drop and increases the surface density for a given size of tubing.

● **Metallurgy and manufacturing problems.** At the high operating temperatures required for thermal efficiency in the gas turbine the demands made of the metals employed in its manufacture are inordinately severe.

Two machines—the high-pressure and the low-pressure turbines, and a considerable part of the duct work—operate at a temperature high enough to make the steel visible in the dark, i.e., at red heat. The physical characteristic of metals at these high temperatures present a problem in itself.

Not only is the strength of metal reduced at high-temperature, but also the phenomenon known as "creep" becomes apparent when exposure to high-temperature is prolonged. This phenomenon exhibits itself as a growth or elongation of the material when subjected to load, and the rate at which this elongation takes place is governed by material, load applied, and temperature.

Because of creep it is certain that, after some period of operation, the turbine rotors will grow, the flat-sided ducts will bulge, and the round ducts will grow too large and too thin. The problem is to choose materials, and loadings, of such character that these changes will not be obnoxious before a certain definite time in terms of hours of operation. The present plant is designed for 10 years' continuous high-temperature operation.

Fig. 6 is a schematic cycle showing materials and temperatures in all major parts of the plant. As will be seen, a fair gamut of materials has been run on this turbine. The nickel torrodial joints in the high-pressure combustion chamber inlet were an interesting problem. The duct is made of chrome molybdenum steel to operate at temperatures

(Continued on Page 108)

HYDRODYNE VALVE ACTUATOR

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The inherent advantages of hydraulic operation provide two other outstanding characteristics: (1) the Hydrodyne Actuator is completely free from the "hammer-blow" action of other actuating devices, and (2) maintenance of this Bendix development has been reduced to routine inspection because the hydraulic oil serves as a lubricant for all moving parts.

A reversible electric motor of relatively small horsepower drives the oil pump in either direction to supply oil under pressure to actuate the valve. All electrical units are enclosed in explosion proof housings.

Hydrodyne Actuators are available for use on valves from 4" to 36" and can be applied to most types of valves. They can be set to actuate at speeds ranging from 12" per second to 6" per minute. Complete auxiliary indicating and regulating equipment can be provided.

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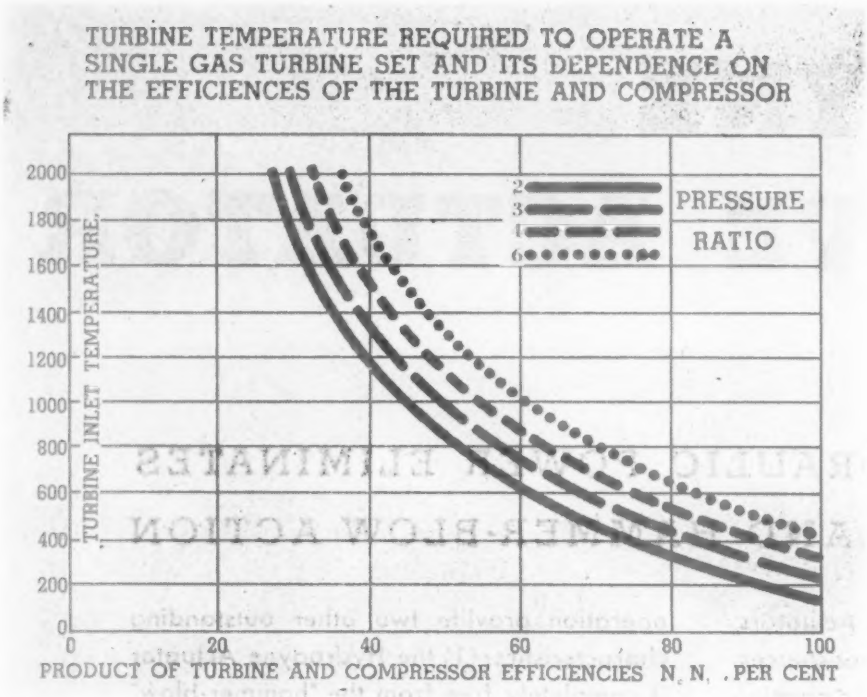


FIG. 4.

(Continued from Page 104)

up to 1000°F. The torrodial joints are spinnings 0.025 in. thick. If made of chrome moly steel, they would be subject to scaling, which would be dangerous because the material is already of minimum thickness. Austenitic stainless steels, having a higher coefficient of expansion than chrome molybdenum, would cause intolerable differential stresses; and ferritic stainless steel cannot be spun successfully. Copper alloys have high coefficients of expansion, but very poor high-temperature properties. Nickel is usually a work hardening material that cannot be spun, but at Elliott's request, a special grade of nickel that could be spun was produced in very small quantities.

The use of high-temperature materials creates so many manufacturing problems that the only possibility of successful construction came through close cooperation between the manufacturing design departments. Castings, although simple to design, are hard to produce in high-temperature alloys, and do not have high-temperature properties of rolled, or forged, material of the same analysis. Because riveted joints depend primarily on tension in the rivet, they can be used only in minor attachments.

In general, the only recourse in building such machines as this is to use rolled plate and arc welding, and by this method fabricate many pieces into one permanent single assembly. This method of fabrication was used in all duct work and combustion chambers. The turbine rotors are assemblies machined from rolled plate and forgings and welded into an assembly.

The extended use of welding in the gas turbine provided some interesting problems in connection with welding on materials fit for high-temperature service. In instance, SAE 4130 chrome moly steel is of an air hardening variety. There is considerable danger that when a weld is made, the heat of the weld will cause an extremely hard, brittle zone directly adjacent to the weld. This characteristic is more pronounced in heavy material than in light due to the quicker cooling of the welds. As a result, it is necessary to check each weld, prior to its being made, to set up procedures and to determine whether or not preheating is required.

The welding of 19-9 WMo material was a completely new problem. No welding had been done with this alloy prior to that in the present plant. It was, therefore, necessary to develop a welding electrode, for all existing electrodes were tested and found short of the necessary high-temperature strength.

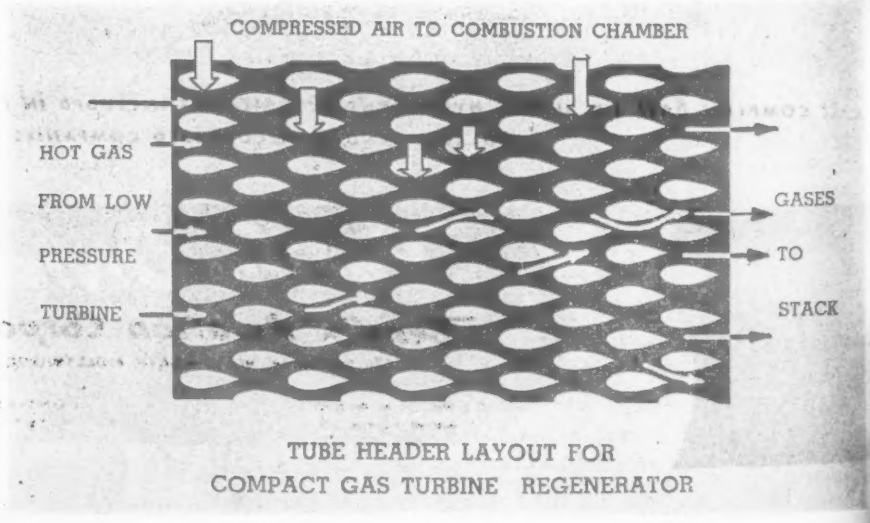
Not only did the new electrode have to possess strength, but tests were necessary to ascertain the operating characteristics of the electrode as there were some very difficult welds on the job. When the heat operating characteristics were obtained, extended tests were made to determine the best procedures to use in laying weld metal. During these tests trouble was encountered in connection with cracks in the welds. This trouble was found to be a matter of analysis of the core wire used in producing the electrode. Without going through all these stages, there would have been little chance of building the high- and low-pressure rotors for the turbines.

In designing the rotors for the large Elliott-Lysholm compressors, it was necessary to use steel shafts. Steel is not a good material for the rotors themselves, however. This presented a problem of attaching the steel stub shafts into cast-iron rotors. Several methods were studied, but the most advantageous from the standpoint of design appeared to be by low-temperature braze.

Low-temperature brazing, or silver soldering, is a well-known process and is used extensively on small parts, but it has been used very little on parts as large as the compressor rotors. Tests were made to learn under what circumstances predictable joints could be made in large parts. As a result, the brazing material was placed properly, a method of cleaning and fluxing the material developed, and a heating cycle procedure set up that assured good silver brazed joints in attaching the stub shafts in the compressor rotors.

The regenerator requires a large number of joints that transmit heat from the tubes to the fins. Some idea of the number of joints can be realized from the fact that there are over 8½ miles of nickel tubing in the regenerator. These joints had to be of such type as to retain strength at a temperature exceeding 1000°F. With considerable testing, and numerous changes, a method was developed for building these regenerators from nickel tubing and sheets by a copper brazing process. The copper brazed joint, as used, is a good carrier of heat and relatively inexpensive to make. When completed the brazing job is clean and free of scale of any kind.

FIG. 5.



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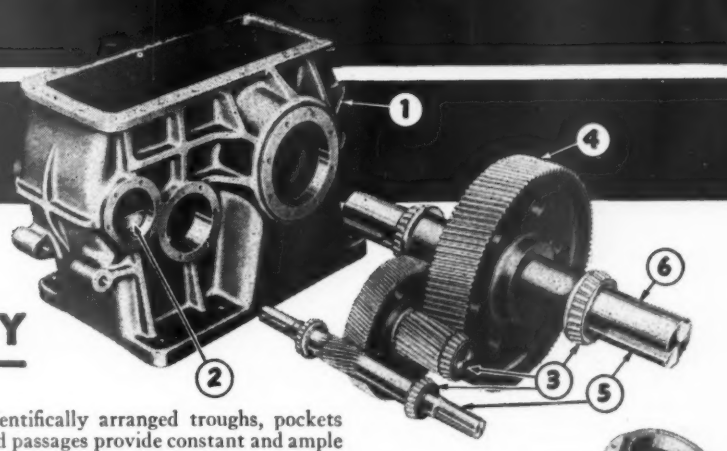

FIELD RECORDS SHOW that repeated torque surges through the reduction gears are the chief cause of most pumping-unit maintenance problems. Likewise, operating economies are equally dependent upon the efficiency with which gears transmit power from prime mover to walking beam.

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1 Heavily ribbed cases, which assure permanently rigid bearing mountings, are symmetrically proportioned so that all shafts may be reversed to utilize all gear-tooth contacts.

2 Scientifically arranged troughs, pockets and passages provide constant and ample lubrication when starting and at all speeds.

3 Heavy-duty, tapered-roller bearings are used throughout to achieve exceptionally high efficiency and provide easy adjustment, making it possible to maintain correct mesh of gears and accurate shaft alignment.

4 Precision-hobbed, single-helical gears, which require no end float, are made of heat-treated steel for prolonged gear life. Pinion gears are cut integral with shafts.

5 High-speed and low-speed shafts of fully heat-treated alloy steel, are equally extended at both ends to permit complete flexibility of application.

6 Each low-speed shaft extension (except on smallest size) has three keyways, 120 degrees apart, so that crank positions can be changed easily to distribute wear on gear teeth.

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. . . is soundly engineered to take maximum advantage of the many outstanding characteristics found exclusively in "Oilwell" Reduction Gears.

"Oilwell" TC-8B Pumping Unit . . . one of two Models for Light-Duty Service.

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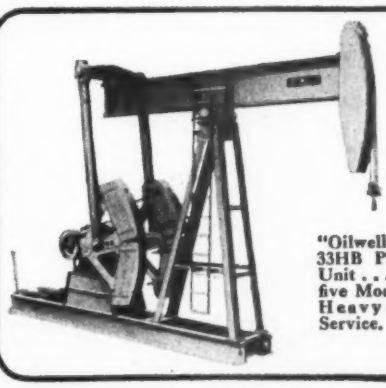

"Oilwell" TC-33HB Pumping Unit . . . one of five Models for Heavy-Duty Service.

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● **Temperature problems.** Both the high- and low-pressure turbines are solidly mounted at their exhaust ends, with all expansions taking place toward the inlet of the machines. In order to permit this expansion, it was necessary to secure these floating ends by means of freely moving links. Relative movement between the turbines and the compressors they drive is absorbed by double flexible couplings and long torque tube jack shafts.

Other temperature expansion problems are found in the pipes that connect the various units. Flexible joints of conventional type are either not satisfactory for the temperatures or pressures encountered, or they are too large for use. It was, therefore, necessary to develop a new type expansion joint.

The temperature of the high-pressure turbine inlet reaches 1230°F., and at a point only 10 in. away, the metal temperatures must be below 200°F. for proper operation of the main shaft bearings. To make this possible, special methods were employed to prevent free conduct of heat to undesired locations, which resulted in the use of heat dams and special oil cooling at the bearings, and air cooling at the pin rings. The pin rings at each end not only support the full weight of the turbine, but they are so constructed that a 600°F. temperature drop takes place in the connections between them and the inlet casing by using small areas of contact, reduced metal sections to cut down heat conduction, and some well-placed air cooling on the inside of the pin rings.

A further temperature drop takes place in the bearing casings, and here again a problem exists. The inside flange of the bearing casing reaches 550-600 °F., but 5 in. away the temperature can be only 200°F. This makes it necessary to have symmetrical and uniform sections for casing walls to prevent excessive and uneven temperature strains.

The shaft is designed in similar manner. The stub shaft ends have reasonably light walls so that the heat conduction is kept to a minimum. A radiation shield is installed inside the shaft to prevent exposure of the cool end of the shaft to the red hot inner regions. In addition, oil cooling is provided under the bearing journal sleeves.

All main members are tied together by means of radial pins that permit free movement between adjacent parts that experience temperature differences. The pin rings, diaphragms, and gland assemblies are all free to expand with respect to their adjoining members. This is a heat-elastic design and construction that has eliminated many of the problems encountered by designers.

A method of unbolting the machines after operation at high temperatures had to be devised. The stainless steel alloy used in the turbine has the undesirable characteristic of galling when 2 parts are assembled, making it impossible to take the nuts and bolts apart unless a suitable compound is previously used on the threads. A great many such compounds are sold, but none proved satisfactory, and it was necessary to devise a special colloidal compound.

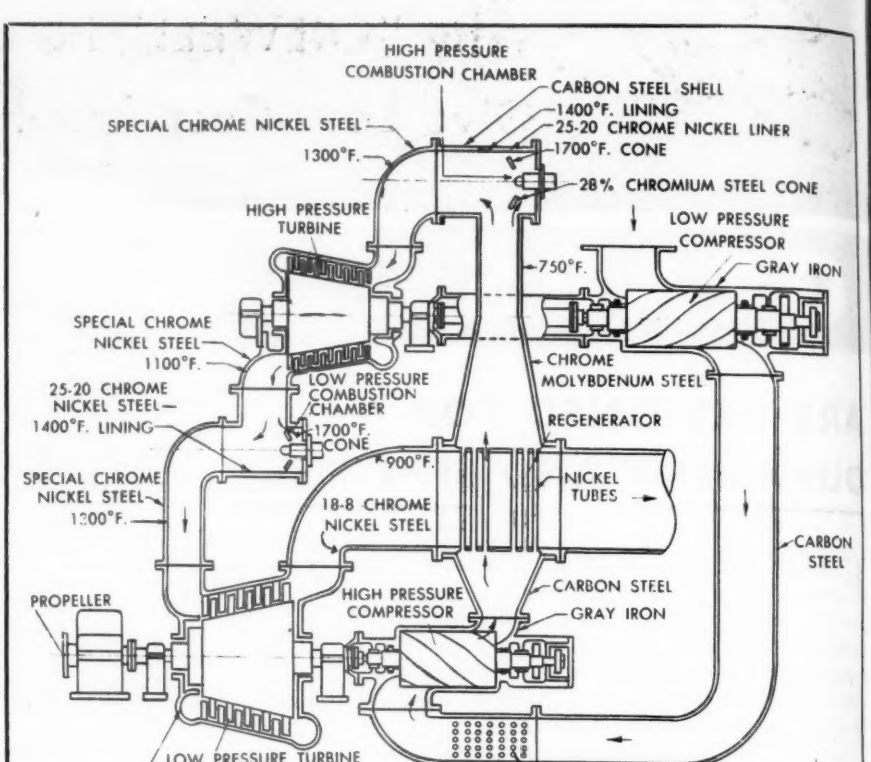


FIG. 6.

● **Future applications of the gas turbine.** Elliott Company has built gas turbines as small as 2½ hp. and as large as 2500 hp. Although it is reasonably certain that units of greater than 2500 hp. capacity are practicable, officials are of the opinion that there is a reasonable doubt that either very small or very large gas turbine power plants will be commonplace in the foreseeable future. They further state that the gas turbine, without displacing other forms of prime movers, has advantages that will win for it a wide sphere of influence. Working with air, which is always present in ample volume; capable of construction in forms requiring little water cooling; light in weight, small in space, and suitable for high rotating speeds; and now proved efficient in operation—these are cited as features that make the gas turbine ideally suited for mobile power plants.

In the most mobile field—aviation—the application of the gas turbine is undergoing rapid development. New fighter planes are propelled by turbine-jet units. Installations of similar types are being applied to bombers, and plans are underway for combination propeller and jet units for airplanes of the future.

In the marine industry, the gas turbines has a wide field of application by virtue of its light weight, compact size, efficient operation over a wide range, simplicity, and potential reliability.

The gas turbine has also a wide field of application in railroad service.

For years, engineers in the power industry have been intrigued by the possibility of packaged power units complete in themselves, capable of transport on skids, and of being set up and operated immediately upon arrival at the site. Because of its freedom from cooling water demands, the gas turbine is ideally suited to an installation of this type.

With the exception of the single-stage turbines now driving jet aircraft power units, gas turbine applications have been as auxiliaries (super-charging) or as an adjunct to oil refining operations. A number of reaction turbines—axial flow compressor sets pioneered by Brown Boveri of Switzerland—have been successfully employed in catalytic cracking. The positive displacement compressor is naturally applicable in this field, and, in fact, when air requirements decline below 20,000 cu. ft. per min. it may have distinct advantages. The gas turbine is ideal for driving such compressors.

● **Acknowledgments.** This article is a composite digest of papers presented at the demonstration by the following officials of the Elliott Company, to whom acknowledgment is made.

C. R. Soderberg, consulting engineer, "Gas Turbines and Other Prime Movers."

W. A. Wilson, mechanical division engineer, "Problems Involved in Gas Turbine Development."

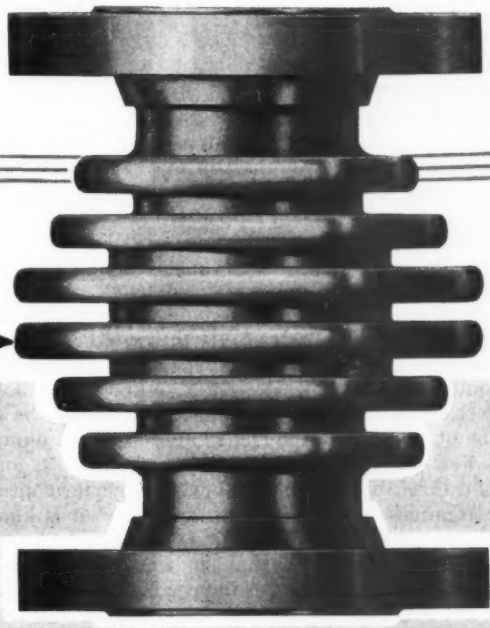
M. A. Mayers, process division engineer. "Heat Supply for Gas Turbine."

R. B. Smith, vice president of engineering, "Future Applications of Gas Turbines."

R. A. Riester, assistant mechanical division engineer, "Layout of Experimental Gas Turbine Unit."

J. F. Cunningham, manufacturing division engineer, "Some Manufacturing Problems in Construction of a Gas Turbine Power Plant." ★★★

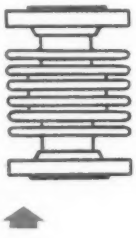
"Clinch-lock" solves expansion joint problems for excessively high pressures . . .



The globular type "MagniLastic" "clinch-lock" expansion joint.

THE newest member of the Cook line of "MagniLastic" expansion joints is the "clinch-lock" type, designed especially to meet requirements where excessively high pressures must be accommodated. An example of this type of expansion joint construction is illustrated at the right. This bellows is made of a high tensile Zirconium alloy steel. The copper brazed "clinch-lock" joint, also illustrated, increases the shearing strength at the joint over the shearing tensile strength of the actual metal itself. The metal has a tensile strength of 152,000 p.s.i., — but when "clinch-locked" and copper brazed in atmosphere controlled, electric furnaces, a tensile strength of 187,000 p.s.i. is developed. The complete bellows assembly is then stress relieved and heat treated.

Two designs of "clinch-lock" expansion joints are available, the globular and parallel shapes. The globular type is especially suited as an expansion and misalignment member and is designed so that the center diaphragms have a longer flexing span than the end diaphragms, enabling a greater hinging action at the center to produce angular displacement and distribute stress forces evenly through the entire bellows assembly, thereby eliminating concentration of these stresses at the ends. This construction, forming a spherical outline makes it unnecessary to use any additional spacing bars or rings and gives uniform proportional travel to each diaphragm in relation to stress forces created.



The parallel or standard type "clinch-lock" expansion joint construction, where expansion alone is accommodated, is constructed with flanges of identical diameters. Both types are manufactured for all pipe sizes, with pressure ranges from 300 lbs. p.s.i. upwards.

The "clinch-lock" type of expansion joint represents only one of a series of high pressure expansion members. Expansion joints of other materials, such as stainless steel, Monel, Inconel and all types of metals, are manufactured to meet specific problems relating to corrosion, elevated temperatures, and other factors encountered in the specific applications. Write for details.

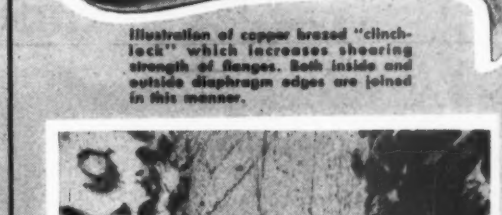


Illustration of copper brazed "clinch-lock" which increases shearing strength of flanges. Both inside and outside diaphragm edges are joined in this manner.

Photomicrograph of copper brazed "clinch-lock" at joint. Note penetration of copper into the metal itself.

PATENTS PENDING

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Some factors entering into

PUMPING UNIT WALKING BEAM SELECTION

By **KENNETH N. MILLS**
Works Manager, Texasteel Manufacturing Company

EXCLUSIVE THE length of the walking beam on a pumping unit is the predominating factor governing the cost of a pumping unit, for it determines the amount of material required in the beam, base structure, and foundation. The conventional relationships between crank stroke and walking beam length preclude the possibility of building an economical long stroke, small load capacity pumping unit for use in pumping small wells at slow speeds with a long stroke. As the application of the slow speed, long stroke theory of pumping has given increased sucker rod life in practically every application, it is highly desirable to know how to build an economical pumping unit for this type of service. To build a pumping unit of this type, it is essential to know how the relationship between crank stroke and beam length affects the performance of the pumping unit, the loads imposed on the pumping system, and how other dimensions affecting pumping unit geometry should be adjusted to obtain optimum performance. From past investigations of pumping unit geometry[1] it is known that the geometry of the pumping unit will affect the torque load imposed on the driving mechanism, the acceleration imposed on the rod string, and the loads imposed on the pumping unit structure and bearings. Due to the variations in actual oil wells, these factors can not be evaluated by actual tests and therefore must be evaluated by analytical investigation using average load characteristics and accepted theory on the response of the load system to those factors that cannot be averaged.

As an investigation of this type would require a large amount of work if existing knowledge of the problem were neglected, only certain informative types of pumping unit geometries were investigated. In determining the types of pumping units to be investigated, the results of past investigations were used as a guide. The dimensional characteristics of the pumping unit layouts, chosen for investigation are shown in Fig. 1. As the torque load imposed on the driving mechanism is one of the important considerations, the torque characteristics of each machine were determined. The torque curves for each of these units are shown in Figs. 2, 3, 4, 5, and 6. These torque curves were determined by entering values of well load obtained from the typical dynamometer card shown in Fig. 7 in the following equation:

$$T = \frac{W \times A \times C}{B}$$

Where:

T = torque, in.-lb.
W = instantaneous well load, lb.
A = normal distance from polished rod to beam saddle bearings, in.
B = normal distance from beam saddle bearing to center line of pitman, in.
C = normal distance from center of crankshaft to center line of pitman, in.

The typical dynamometer card was determined by averaging

(Continued on Page 116)

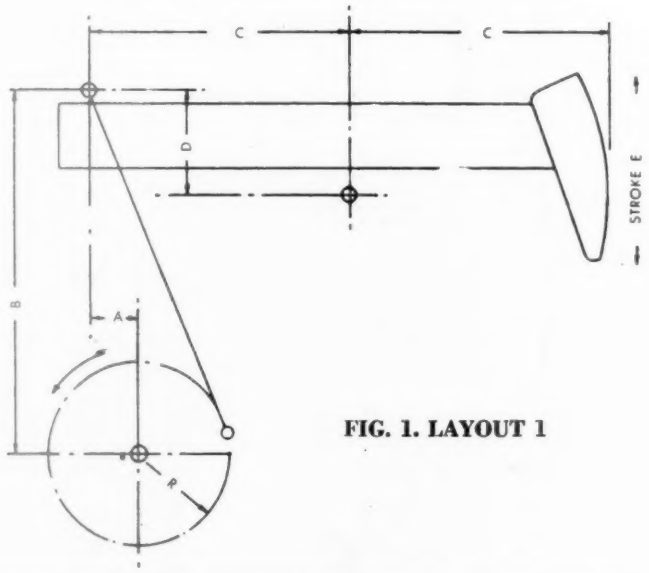


FIG. 1. LAYOUT 1

Dimension	LAYOUT No.				
	2	2A	2B	2C	2D
B/R	3.52	3.39	3.38	3.38	4.15
R	27"	32"	37"	37"	37"
E	56½"	66¼"	77½"	75⅝"	75¼"
D	29¼"	28⅝"	28⅝"	28⅝"	35½"
C	7' - 0"	7' - 0"	7' - 0"	7' - 0"	12' - 9"
B	7' - 11¼"	9' - 0⅝"	10' - 5"	10' - 5"	12' - 9½"
A	11"	12⅞"	16⅞"	11"	11½"

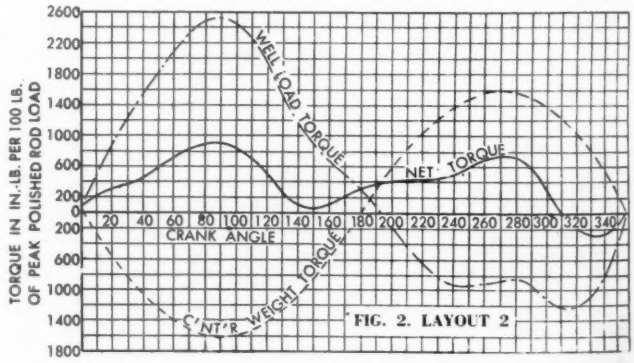


FIG. 2. LAYOUT 2

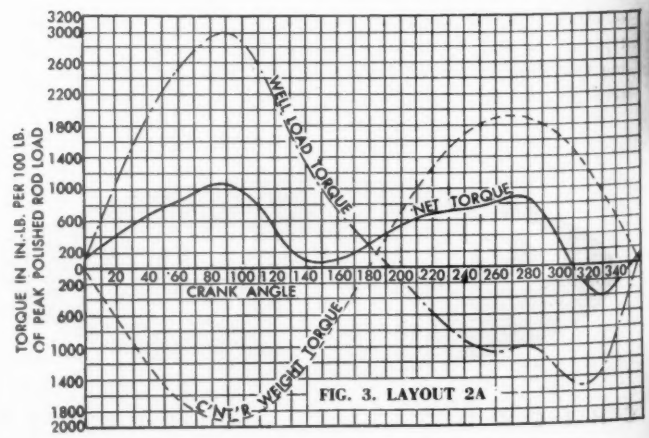
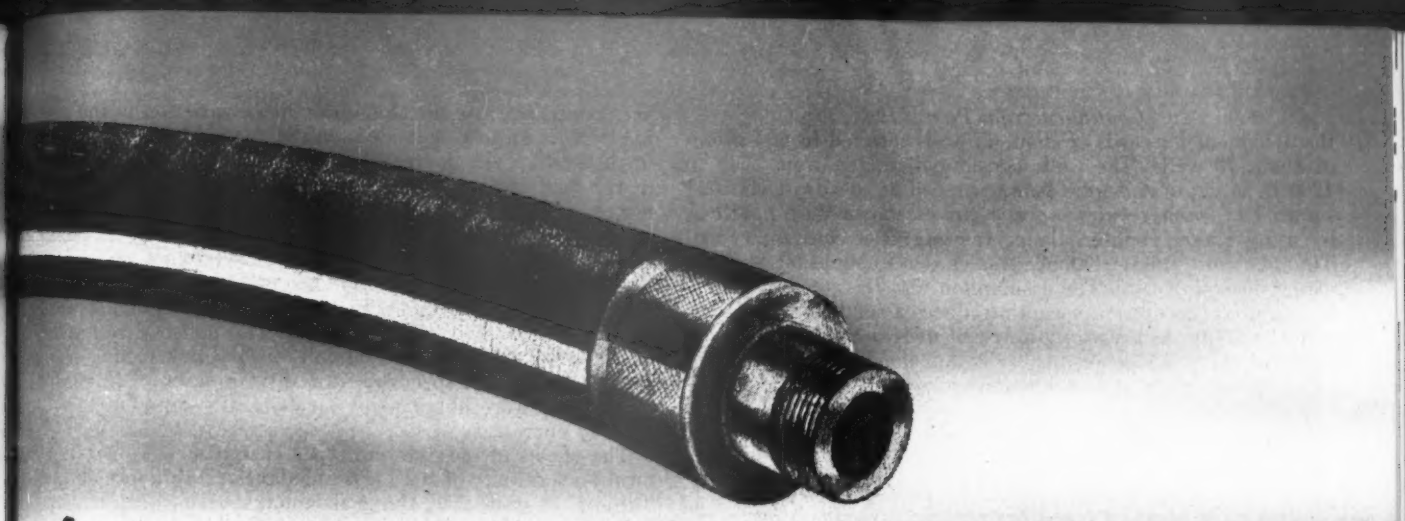


FIG. 3. LAYOUT 2A



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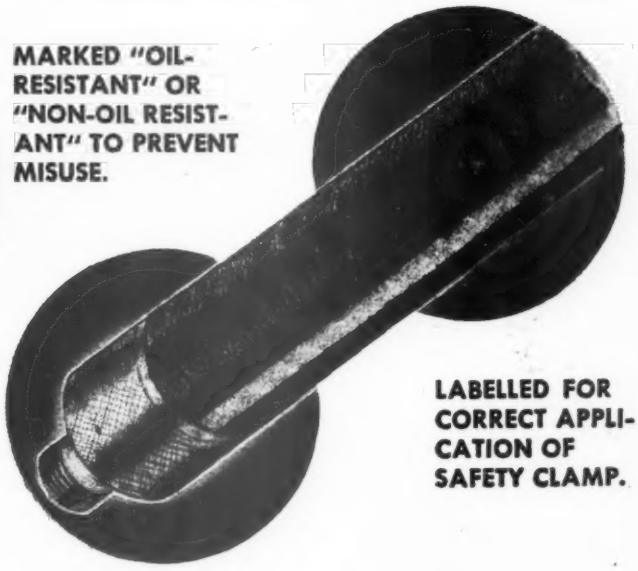

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(Continued from Page 112)

the dynamometer cards of about 35 wells selected from a group of about 70 wells. The wells considered ranged from 2000 to 4200 ft. in depth and were being pumped at speeds of 16 to 25 s.p.m. The counter-weight torque curves shown were obtained by using rotary counterbalance rotating at a constant speed. The maximum counterbalance was chosen to equal 60 per cent of the peak well load. The assumption that the counterbalance is rotating at a contsant speed introduces a small error. As this error exists in each case, however, it does not affect the comparative value of the results. If it did affect the comparative value of the results, it would be impossible to predict the results accurately, because the amount of speed variation in the pumping cycle is largely dependent on the amount of rotating inertia in the system, the degree of proper counterbalance, the prime mover load factor, and the torque characteristics of the prime mover.

Although polished rod velocity and acceleration have only a minor effect on the magnitude of the maximum polished rod load, these two factors are of interest and should be investigated. Polished rod velocity and acceleration curves for each layout are shown in Figs. 8, 9, 10, 11, and 12. The polished rod velocity curves were obtained kinematically by the link to link method assuming constant speed of crankshaft rotation. The acceleration curves were obtained by mechanically differentiating the velocity curves.

The effects of the different types of unit layouts investigated on the magnitude of the peak unbalanced torque are shown in Table 1. In each case, the peak unbalanced torques have been corrected to the crank stroke. In this table, it will be noted, the unit with the longest beam gave the greatest unbalanced peak torque.

The torque values tabulated under the column, "Theoretical peak unbalanced torque based on crank stroke" were found by multiplying the crank arm by 100. The results of dividing this value into the actual peak unbalanced torque are shown in the next column, and it will be noted that in every case the value thus obtained is less than one. This indicates that all rig layouts investigated have mechanical advantage due to their geometry.

The effects of the different types of unit layouts investigated on the magnitude of the peak balanced torque are shown in Table 2. In each case the peak balanced torques have been corrected to the crank stroke and have been corrected so the two peaks will be equal. In this table, it will be noted that the unit with the longest beam gives the greatest peak balanced torque.

The torque values tabulated under the column, "API peak torque based on 60 per cent counterbalance," were obtained by multiplying the crank arm by 40, which corresponds to 40 per cent of the peak polished rod load of 100. The results of divid-

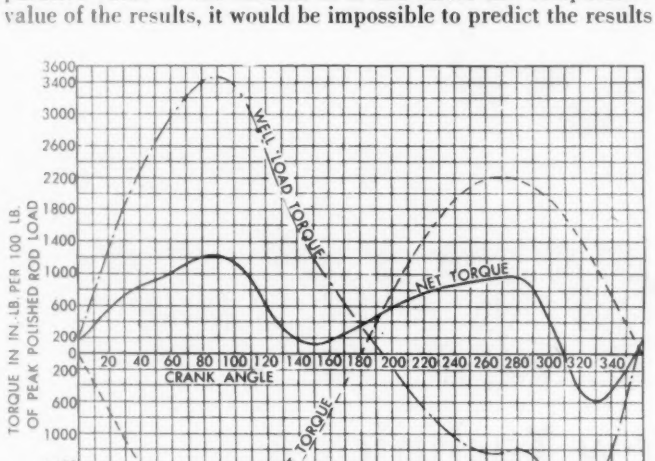


FIG. 4 LAYOUT 2B

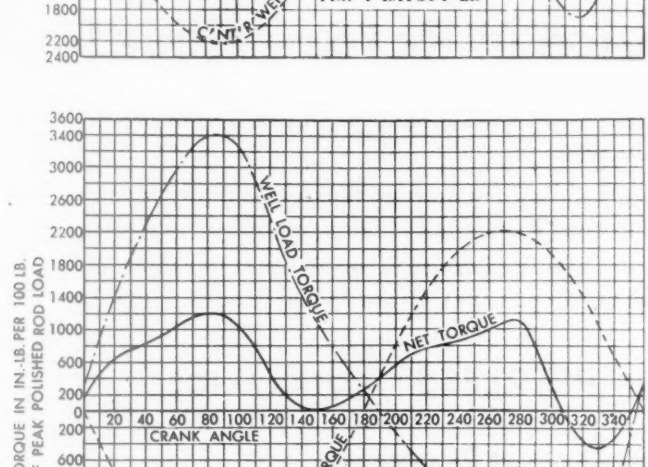


FIG. 5. LAYOUT 2C

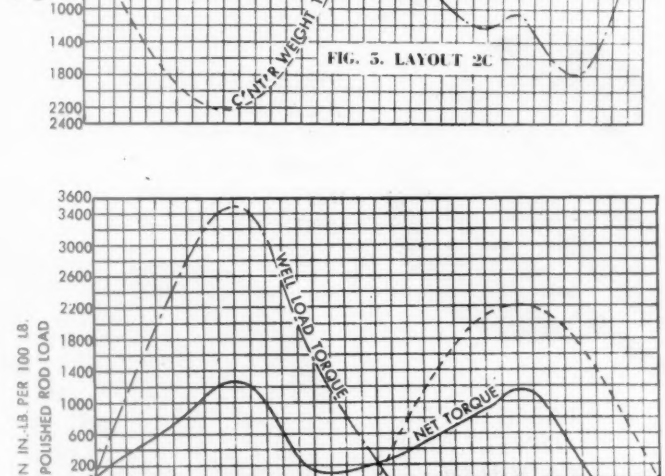


FIG. 6. LAYOUT 2D

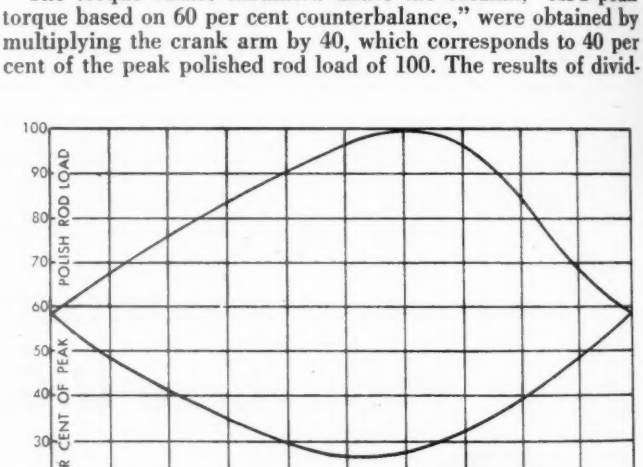
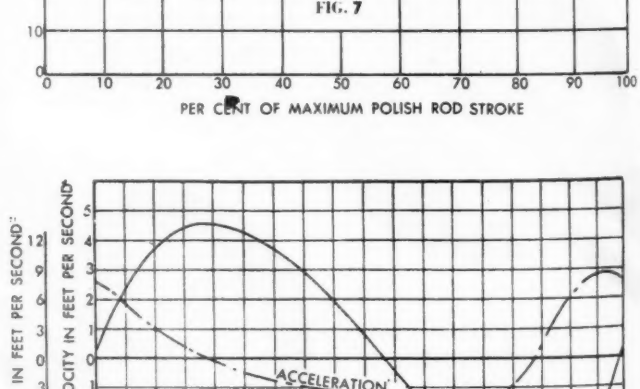


FIG. 7


ACCELERATION IN FEET PER SECOND
POLISHED ROD VELOCITY IN FEET PER SECOND
ACCELERATION
VELOCITY
CRANK ANGLE IN DEGREES FOR COUNTER-CLOCKWISE ROTATION
FIG. 8. LAYOUT 2

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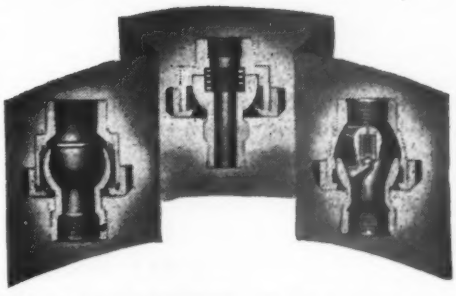

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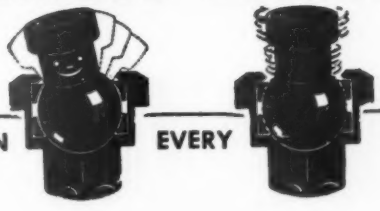

Not just a swivel joint . . . but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

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TABLE 1

Comparison of unbalanced peak torques.

Rig layout no.	Crank stroke, in.	Polished rod stroke, in.	*Peak unbalanced torque corrected to crank stroke	*Theoretical peak unbalanced torque based on crank stroke	Actual peak unbalanced torque corrected to crank stroke divided by theoretical peak unbalanced torque
2	54	56.5	2410	2700	0.893
2A	64	66.25	2900	3200	0.905
2B	74	77.50	3295	3700	0.890
2C	74	75.63	3340	3700	0.903
2D	74	75.25	3440	3700	0.930

*Torque units—In-lb. per 100 lb. peak polished rod load.

ing this value into the actual peak torque are shown in the next column, and it will be noted that in every case the value thus obtained is less than one. This indicates that, for the conditions used, the actual peak torque imposed on the gear train will be less than that found by the suggested API method.

TABLE 2

Comparison of balanced peak torques.

Rig layout no.	Crank stroke, in.	Polished rod stroke, in.	*Peak balanced torque corrected for ideal counterbalance and to crank stroke	*API peak torque based on 60 per cent counterbalance	Corrected peak balanced torque divided by API peak torque
2	54	56.50	794	1080	0.734
2A	64	66.25	947	1280	0.740
2B	74	77.50	1055	1480	0.713
2C	74	75.63	1135	1480	0.767
2D	74	75.25	1200	1480	0.811

*Torque units—In-lb. per 100 lb. peak polished rod load.

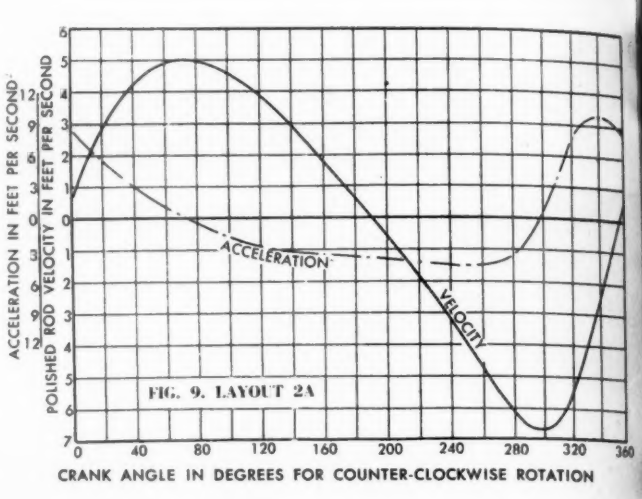
The effects of the different types of unit layouts investigated on the magnitude of peak polished rod acceleration is shown in Table 3. In each case, the acceleration shown corresponds to a pumping speed that will give equal average polished rod speeds, and therefore, they are all comparable, regardless of the length of crank stroke. As the value of the peak acceleration is of little value, because it is not a direct indication of the effect of acceleration of the system, no attempt has been made to compare these values. The acceleration factor, which is $1 + \frac{\text{Acceleration}}{32.2}$ is the item that is of interest, because it is the one that directly affects the magnitude of the dynamic load. In this table, it will be noted that the unit with the longest beams gave the lowest acceleration factor. It will also be noted that the differences in the values of the acceleration factors obtained from the various units is relatively small.

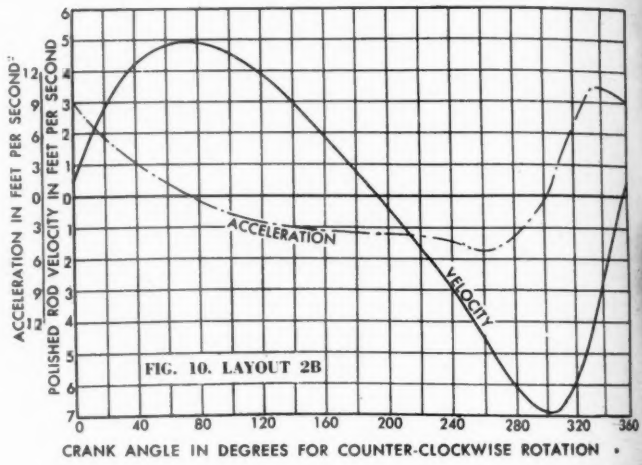
The peak torque values obtained indicate that for the conditions investigated the beam working centers have very little affect on the torque values, as the indicated result is a reduction in the peak torque load. As this investigation did not include all possible types of unit geometry, definite dimensional limitations cannot be drawn, but it should be noted that relatively long pitmans were used on all machines investigated. These long pitmans were used because it is believed that the length of the pitman is one of the predominating factors affecting the operation of the pumping unit. This thought is based

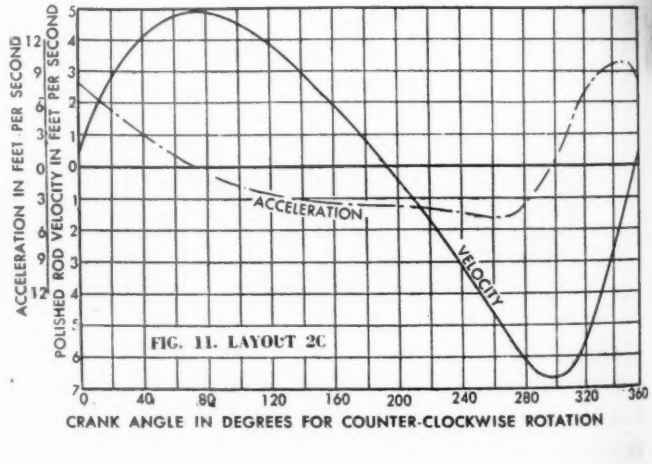
TABLE 3

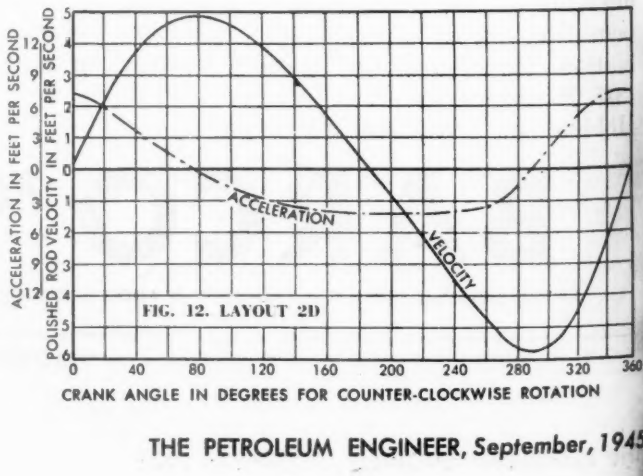
Comparison of polished rod accelerations.

Rig layout no.	Crank stroke, in.	Peak polished rod accel. based on a crank speed that will give the same average polished rod velocity as is obtained on rig layout no. 2 at 20 s.p.m. ft./sec/sec.	Polished rod accel. factor $1 + \frac{\text{Accel.}}{32.2}$	Per cent increase in polished rod accel. factor over lowest value
2	54	8.46	1.263	2.94
2A	64	9.36	1.292	5.30
2B	74	9.85	1.306	6.44
2C	74	9.50	1.295	5.55
2D	74	7.32	1.227	....

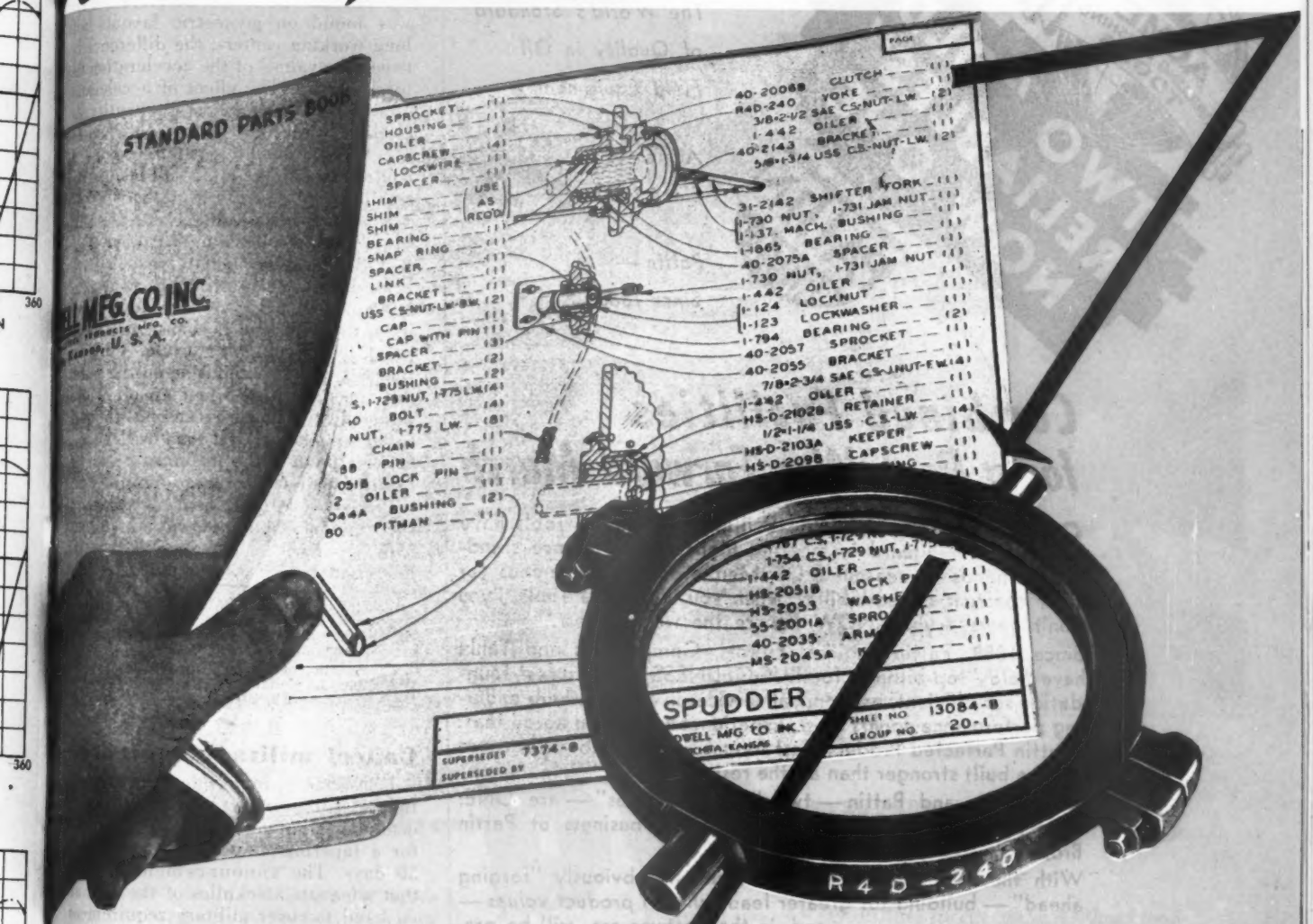

ACCELERATION IN FEET PER SECOND
POLISHED ROD VELOCITY IN FEET PER SECOND
ACCELERATION
VELOCITY
0 40 80 120 160 200 240 280 320 360
CRANK ANGLE IN DEGREES FOR COUNTER-CLOCKWISE ROTATION
FIG. 9. LAYOUT 2A

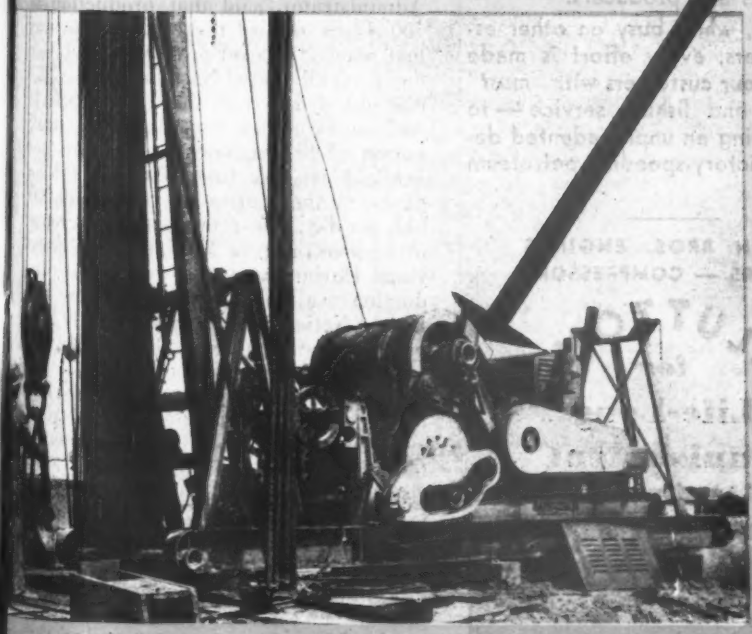

ACCELERATION IN FEET PER SECOND
POLISHED ROD VELOCITY IN FEET PER SECOND
ACCELERATION
VELOCITY
0 40 80 120 160 200 240 280 320 360
CRANK ANGLE IN DEGREES FOR COUNTER-CLOCKWISE ROTATION
FIG. 10. LAYOUT 2B


ACCELERATION IN FEET PER SECOND
POLISHED ROD VELOCITY IN FEET PER SECOND
ACCELERATION
VELOCITY
0 40 80 120 160 200 240 280 320 360
CRANK ANGLE IN DEGREES FOR COUNTER-CLOCKWISE ROTATION
FIG. 11. LAYOUT 2C


ACCELERATION IN FEET PER SECOND
POLISHED ROD VELOCITY IN FEET PER SECOND
ACCELERATION
VELOCITY
0 40 80 120 160 200 240 280 320 360
CRANK ANGLE IN DEGREES FOR COUNTER-CLOCKWISE ROTATION
FIG. 12. LAYOUT 2D

Worth $1,000 to a "CARDWELL" owner





Your drilling or servicing rig is only as good as the parts replacement service behind it. Fast, efficient service can save you days of downtime or many times $1000 if a well is lost.

"Cardwell" is alive to your needs and has solved this problem with a system of parts stores and machine records that assure fast and accurate parts service.

The key to this system is a parts and instruction book that illustrates and numbers each part to correspond with actual part number. ONLY THIS NUMBER IS NECESSARY TO ORDER A REPLACEMENT PART. Field and office copies of parts books are furnished without charge for each machine, and a master parts book of each machine is on file in a fireproof vault at the factory. To every "Cardwell" owner this insures prompt, efficient parts service on his machine, regardless of its age or model.

Only with a "Cardwell" rig can you obtain this parts replacement service that is easily worth many thousand dollars to you.

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P. O. Drawer 300 Cable Address: ALLSTEEL, WICHITA, CARDSTEEL, NEW YORK

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Combined Facilities for a Post War Forward March

SINCE 1900, Acme's Cable Drilling and Fishing Tools have *led* the vanguard in meeting highest performance standard demands of seasoned Oil Men everywhere. Famous for their *constant* dependability, when you use Acme Tools, "you don't *guess* — you KNOW they're the world's *best*."

Since 1888, Pattin Engines, Powers, Compressors and Tanks have *held* "top-billing" for RUGGEDNESS — the *safest* foundation for efficient, economical service, in a field where enduring performance *counts most*. Experienced Oil Men agree that: "Pattin Perfected Products last longer and serve best, because they're built stronger than all the rest."

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With these combined facilities, Acme is obviously "forging ahead" — building for greater leadership in *product values* — and, in the postwar era, will be prepared to serve a wider world-market, *both* drillers and producers.

Even today, while busy on other essential orders, every effort is made to provide our customers with *"must"* equipment and fishing service — to aid in meeting an unprecedented demand for Victory-speeding petroleum products.

They're "Tougher than Tough!"

Acme Drilling Bits — First choice of Drillers "fighting for ***extra footage.***" Forged to their own specifications, of finest bit steel, and fashioned to perfectly balanced proportions — by 45 years of specialized craftsmanship. They just *naturally* "stand the gaff" — LONGER . . . Made in regular Mother Hubbard or Tapered Shank Patterns. Specify Acme (Alloy Steel) Drilmor Bits for drilling formations too hard for standard bits.

Fig. 108
See
Acme — Composite Catalog.

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on the fact that the motion of the upper end of the pitman would be simple harmonic if the pitman length were infinite.

Although the lowest acceleration rate was found on geometric layouts with long working centers, the difference between the values of the acceleration factors is small. The effect of acceleration on well load is not a definite quantity. According to the best theory, polished rod acceleration is unimportant because its contribution to the total well load is very small[2].

The only disadvantage of the short beam long stroke pumping unit is the fact that it is limited to wire line type beam hangers. The wire line type beam hangers will not give satisfactory service if the well load becomes zero at any point in the pumping cycle. This fact places a definite limitation on the pumping speed because when an oil well is pumped at a speed exceeding about 26 to 30 s.p.m., the well load will be zero at some point in the stroke and wire line failures will occur. If a pumping unit with a short walking beam is applied to the problem of pumping an oil well at a slow speed with a long stroke, however, this disadvantage will not exist.

[1]"Effect of Design and Direction of Rotation on Peak Torque of Pumping Unit" by Kenneth N. Mills and E. A. Olsovsky, *The Petroleum Engineer*, August, 1939.

[2]"Correlation of Polished Rod Acceleration and Well Load" by Kenneth N. Mills, *The Petroleum Engineer*, January, 1944.

★★★

Cancel military contracts

PAW has recommended the termination of all military contracts for 100-octane aviation gasoline with a provision for a tapering-off period not to exceed 30 days. The announcement revealed that adequate stockpiles of the fuel are on hand to cover military requirements for several months.

Ralph K. Davies, Deputy Petroleum Administrator, said that production of 100-octane toward the close of the war had reached a level of 600,000 bbl. per day from all United Nations plants, 525,000 bbl. a day from the United States. Although complete records for the peak period of the high-octane fuel are not available at this time, Davies said he expected the figures to reach 530,000 bbl. per day. This represents an increase of approximately 750 per cent since Pearl Harbor when the worldwide production available to what are now the United Nations was less than 80,000 bbl. per day, of which about 58,000 bbl. was produced in the United States.

Five months before Pearl Harbor PAW took over the aviation gasoline program and since that time, 360,000,000 bbl. of fuel have been produced. A construction program costing approximately $1,000,000,000 was undertaken by PAW in order to effect this tremendous production rate. The construction program was about 95 per cent completed when the war ended. Termination of the 100-octane program will make available adequate supplies for refiners to return to prewar schedules for making various grades of civilian gasoline, Davies said.

—from a field report on the Shock Absorb

BJ DRIVE BUSHING

Important information to the operator looking for the best design in a Kelly Drive Bushing. Through "engineered design" the body of the BJ Kelly Drive Bushing is a solid one-piece unit with corrugated inner bore. Into these corrugations the well-known original BJ rubber shock-absorbing cushion is fitted. The metal slips fitting into this cushion are faced with replaceable liners of special antifriction material. The flat surfaces of these inexpensive liners are all that wears in a BJ Kelly Drive Bushing. They are reversible for long life, positively retained on the slips for safety, but easily replaced.

New Kellys last longer, wear evenly and are not "washboarded."

Even where worn and battered Kellys are employed, and at modern-day drilling speeds, these BJ liners tend to smooth and polish the Kelly, while feeding it evenly and safely with accurate maintenance of the exact desired weight on the bit.

The body is designed to take the different size slips to fit any square Kelly. And, as the field reports indicate, it is seldom necessary to replace the amazingly long wearing liners.

For better coring, more efficient drilling, and elimination of the "twist off" danger, equip your rig with an economical BJ Kelly Drive Bushing!

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P 533.25

LA GOLETA NATURAL GAS STORAGE PROJECT*

RAYMOND W. TODD
Pacific Lighting Corporation

THE supplying of natural gas to the Southern California area presents many interesting and varied problems. In the first place, the gas companies are almost wholly dependent upon oil well gas as a primary source of gas for distribution. Inasmuch as the production of oil well gas is dependent on the production of oil, the supply of gas is more or less fixed at a constant rate. The amount of oil well gas available for consumption by customers in Southern California is approximately 450 million cu. ft. daily.

Raymond W. Todd

Normally this production of oil well gas exceeds the market requirements during the summer months, or off peak period, but fails to meet such requirements during the winter months, or peak period. For example, on February 28, 1945, the gas companies experienced a day of very heavy demand, which resulted in the distribution of 617 million cu. ft. of gas. This load was all firm load, inasmuch as practically all surplus rate curtailable industrial load had been shut off. During this summer there were days on which total actual delivery was less than 350 million cu. ft. This amount included the sale of all industrial gas requirements.

Considering these maximum and minimum load requirements with industrial consumers, off in one instance and on in the other, it is obvious that some means of equating the winter and summer load factor must be provided. The partial answer to this problem has been underground storage of gas during the summer months and its subsequent withdrawal and use during the winter. Before discussing the problems in connection with underground storage of gas, however, there is to be considered another supply problem with which the gas companies are constantly confronted. In addition to having to equate a winter and summer load, it is necessary to provide facilities for equating the daily load. Here in Southern California daily temperature variations are often as high as 40°F. Such temperature fluctuations naturally result in a tremendous variation in gas demand. For example, referring back to the peak day of last February, the maximum hourly delivery at a daily rate was 852 million cu. ft., whereas the minimum hourly delivery at a daily rate was 234 million cu. ft.—a ratio of almost 4 to 1 between maximum and minimum.

In the past such daily fluctuations have been met through the use of dry gas production, above ground storage, pipe line pack and gas manufacturing operations. With the increase in firm load demand, however, it has been impossible to equate fully the load by these means, and it has been necessary to utilize underground storage to alleviate these daily fluctuations. In many instances during the past year gas would be injected in underground storage during the night or off-peak periods and withdrawn during the day or peak period, all within a 24-hr. period.

During the maximum rate of delivery of 852 million cu. ft. of gas on the peak day last winter, gas was withdrawn from underground storage at a rate of 193 million cu. ft. per 24 hr. with 150 million cu. ft. of this amount of gas being withdrawn from the La Goleta field.

From the above load conditions, it is, therefore, apparent that the underground storage projects perform two functions: First, provide means of storage of surplus natural gas during the summer period, making this gas available during winter; and, second, equate daily and hourly fluctuating loads.

Underground structures suitable for gas storage have been sought by the gas companies for many years. Tests have been made on various structures, the majority of which did not prove satisfactory. Some of the conditions that must be taken into consideration in deciding whether a structure will be suitable for gas storage are:

1. The closures of the structure must be such that there is reasonable assurance that the gas injected will be recovered.

2. Water encroachment must not be at a rate that would interfere with the use of the structure.

3. The structure must be of sufficient capacity to warrant the necessary capital expenditure for injection and withdrawal facilities.

4. The permeability of the sand in the reservoir must be such that gas can be readily injected and withdrawn at high rates over an extended period.

5. The sand in the structure must be reasonably free of liquids, which might be picked up by the injected gas and present serious removal problems.

6. The structure must be at a location that would make the transmission of gas to the distribution locations practical.

7. The necessary right to use the structure for storage purposes must be obtainable from the oil companies and/or those holding such rights.

A storage structure need not necessarily meet all the above conditions, but each must be taken into consideration when studying possibilities of gas storage. In most instances, the problem of ownership or rights in the structure, or surface rights, are so complicated that it eliminates the use of the structure for gas storage without considering the other factors.

There are at present several underground gas storage reservoirs being utilized in connection with the conserving and supplying of natural gas for Southern California. The largest and most important of these underground storage projects is in the La Goleta field.

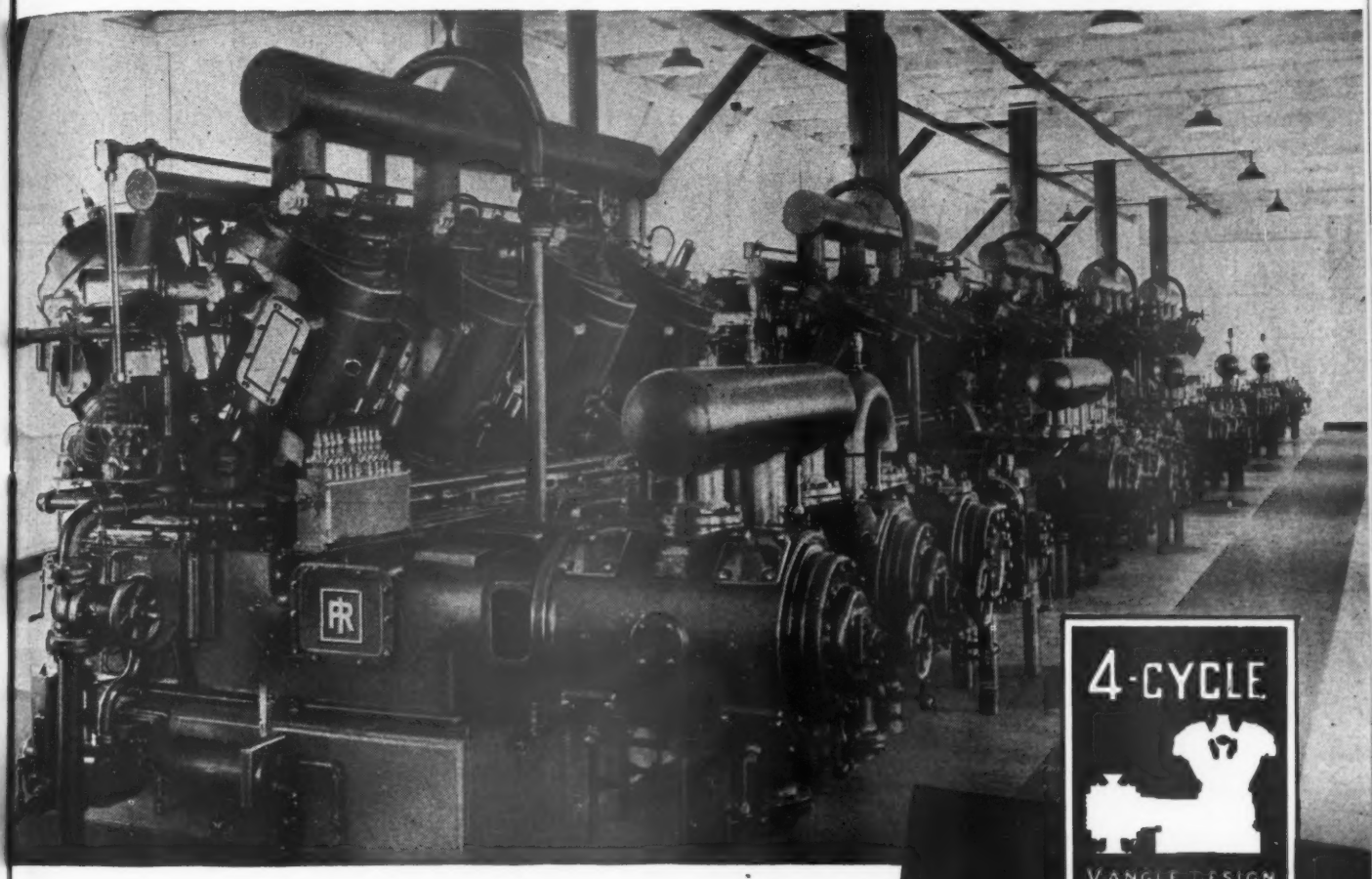
Before going into the details of the La Goleta storage project, I believe it would be advisable to review briefly the history of the La Goleta field. The La Goleta field is on the Pacific Coast, approximately 8 miles north of the city of Santa Barbara. The field was originally discovered by one of the major oil companies in 1929. The formation in which the storage operations are carried on is a Vaqueros sandstone and is approximately 4300 ft. below sea level. The Vaqueros zone has an average thickness of some 300 ft. and is considered ideal for gas storage operations, inasmuch as it has a porosity in excess of 20 per cent. Between the originally discovered well in 1929 and 1935, four additional wells were completed in the structure. All these wells, including the original well, were drilled by major oil companies endeavoring to strike an oil zone, and were not drilled for the production of natural gas. These wells and other wells drilled outside the limits of the field area have defined the productive Vaqueros zone as covering an area of approximately 295 acres.

Unfortunately, the original well head pressure was not observed in the discovery well; however, record of the well head pressure was noted as 1700 lb.

*Presented before California Natural Gasoline Association, Downey, California, August, 1945.

Maintaining the REPUTATION

OF MORE THAN 1500 OTHER 4-CYCLE XVG COMPRESSORS



In this row of gas-engine-driven compressors are eight Type XVG units... all 4-cycle V-angles. The five you see are 300-hp, 3-stage units operating at 1500-lb discharge, returning excess gas to the oil-producing formations in a Louisiana field.

The other three units are about 10 years old, having seen service elsewhere. They are 2-stage compressors operating on gas-lift service, with 400 to 450-lb discharge. Two of them were formerly used by other companies for producing oil wells until the leases were abandoned. The third unit generated Air Power for a glass manufacturer in the North before being installed here.

Each of these XVG compressors has a reputation to maintain... an enviable reputation established by more than 1500 Ingersoll-Rand 4-cycle V-angle units of the same type in service in all parts of the world. This proven combination of the 4-cycle principle and V-angle design offers the best and most modern solution of the gas-engine-driven compressor problem.

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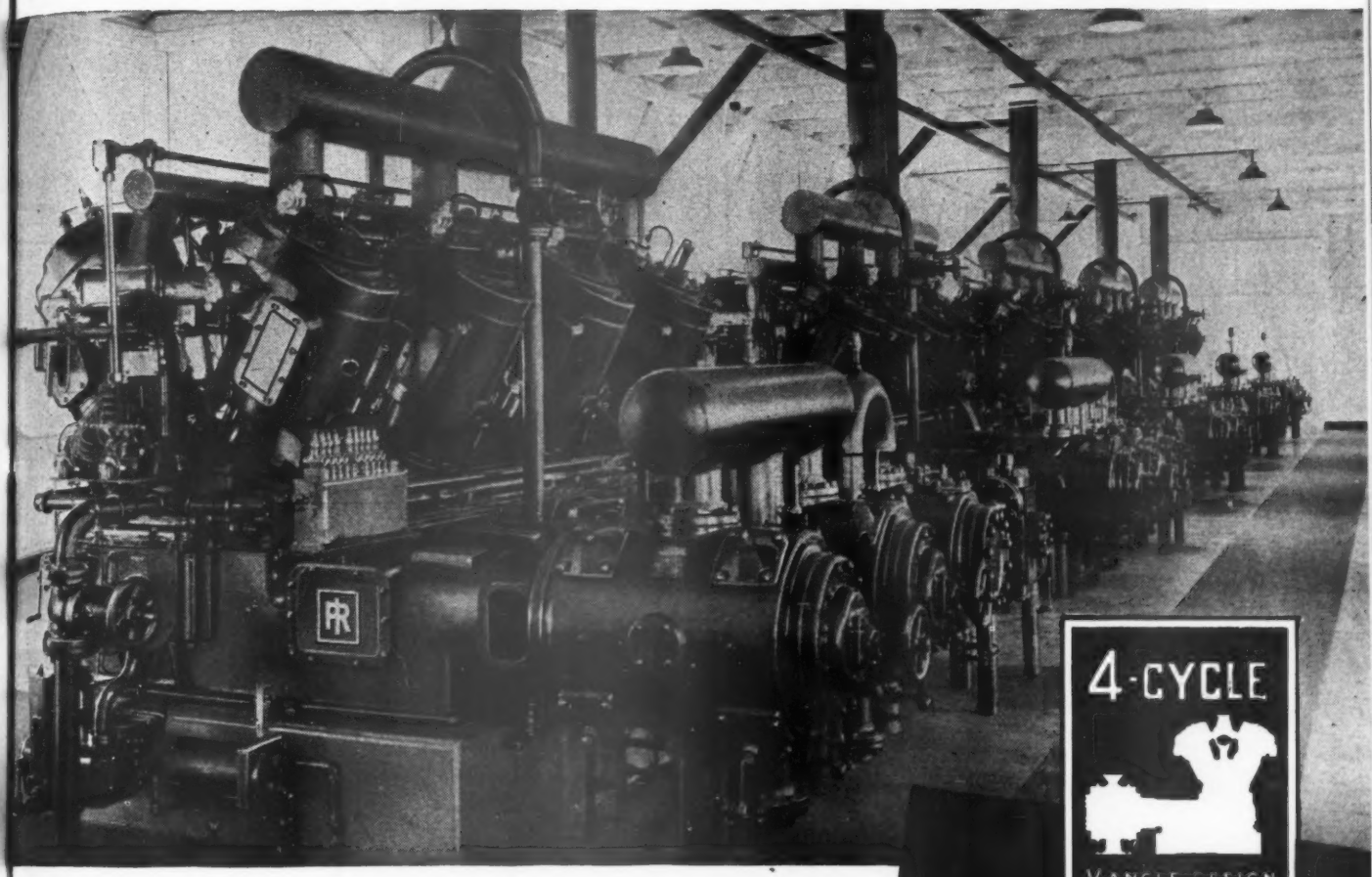

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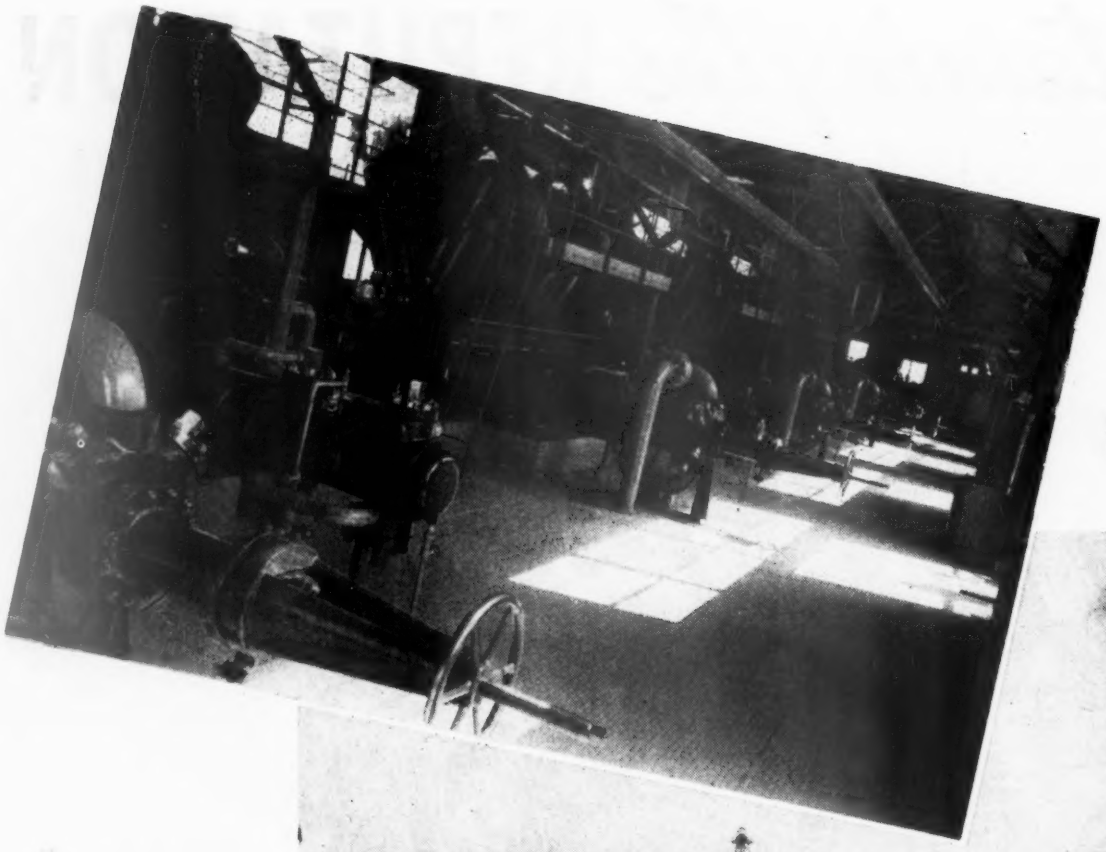
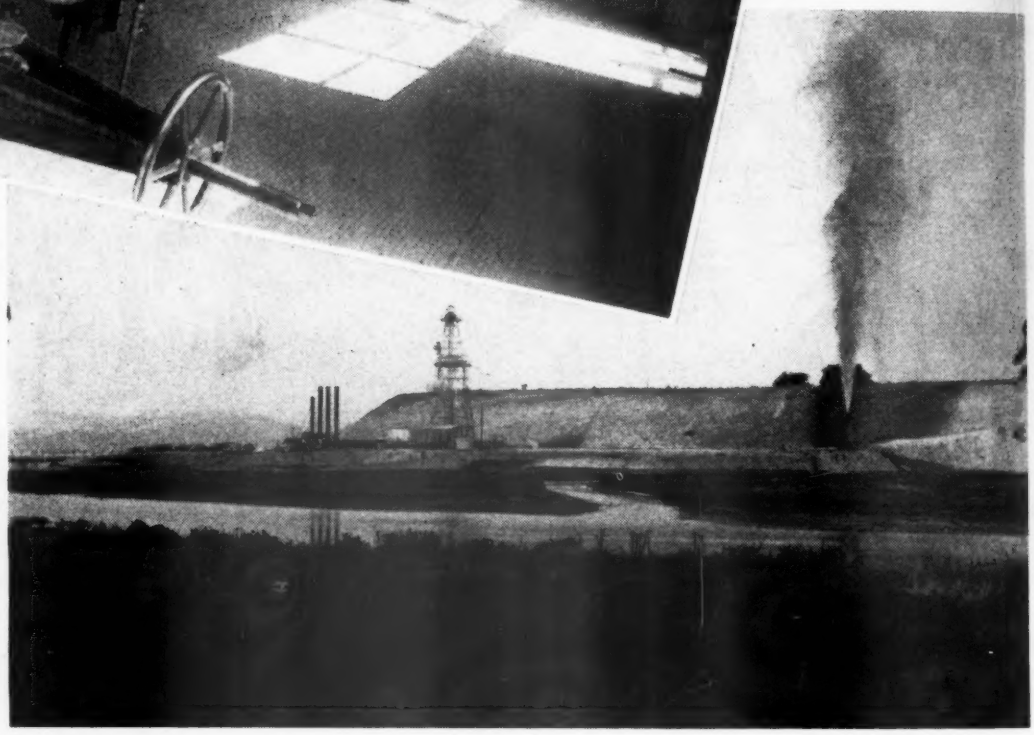


Interior of injection compressor plant.



Miller No. 1 well being cleaned up for production.

per sq. in. gage after several months of testing. This pressure has been considered to be quite accurate, inasmuch as fields of this type generally have a formation pressure equal to the hydrostatic head of salt water, which at a depth of 4300 ft. would be 1904 lb. per sq. in. gage, which pressure corresponds to a surface pressure of approximately 1705 lb. per sq. in. gage.

In order to utilize the gas produced in the La Goleta field, pipe line facilities were installed in 1931, which would allow the withdrawal of gas for use in the Los Angeles area. This withdrawal continued for a period of years up to 1939, during which time 15,300 million cu. ft. of gas was withdrawn from the structure. The production of this amount of gas resulted in the well head pressure being lowered to approximately 1450 lb. per sq. in. gage.

In 1939, the increase in firm load requirements and the necessity of equating the summer and winter loads, prompted the Pacific Lighting Corporation to start tests on the structure to determine the feasibility of utilizing the structure for dry gas storage. The necessary test facilities were installed and during the summer of 1939, several hundred million cubic feet of gas were injected and the resulting pressures observed. The results of these tests indicated that there was no question but that the structure was adaptable for underground storage, and the necessary rights were acquired to use the structure for storage operations. As much of the property as possible was purchased in fee, while on the remaining property all gas between the bottom of the Vaqueros zone and the surface was purchased in place, along with the right to use the structure for storage purposes. The five wells that had been drilled in the field by the oil companies were purchased from them for use as withdrawal and injection wells.

The pipe line facilities originally installed had a capacity out of the La Goleta field of 65 million cu. ft. The original wells drilled by the oil companies had a combined production capacity of approximately 100 million cu. ft., when the wells were operated on the basis of not exceeding 500 lb. draw-down during production. This maximum draw-down pressure was established in order to eliminate a high sand face velocity.

In order to provide sufficient injection capacity to inject the required volume of gas during the summer time to meet the winter withdrawal from La Goleta, Pacific Lighting Corporation in 1941 completed the installation of an injection plant, consisting of four 600-hp. and one 300-hp. gas-engine-driven compressor units. This plant had a total injection capacity of approximately 30 million cu. ft. per day. The compressor plant was designed and constructed to operate at a maximum discharge pressure of 2500 lb. per sq. in gage, and

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Graphite's very low coefficient of thermal expansion—.0000015 per °F—explains why some graphite molds for ferrous and non-ferrous metals withstand several thousand pours without longitudinal or cross-sectional change. Graphite electronic tube components, at temperatures far exceeding operational requirements, maintain an unmatched degree of dimensional stability.

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an intake pressure of 350 lb. Gas for injection was supplied from oil fields in the coastal area.

The operation of the field and its facilities during 1941-42-43 verified the results of the injection test made in 1939, and proved beyond a doubt that the La Goleta field was suitable for gas storage. In 1943 the gas companies were confronted with the problem of supplying additional gas during the winter periods, and providing a means of conserving increased amounts of natural gas during the summer months, which were available as a result of the increased oil production. In view of the satisfactory operations at La Goleta, the La Goleta field was selected as the location for the additional storage operations.

The additional gas necessary to meet the winter load requirements and the capacity for utilizing summer excess gas established the operations of the La Goleta storage project as follows:

Withdrawal capacity **179,000,000**
Injection capacity **65,000,000**

In order to meet these requirements, the following installations were agreed upon:

1. Install a high pressure transmission pipe line from La Goleta to the Los Angeles area.

2. Install 1000 lb. per sq. in. gage compression equipment at Ventura in order to provide gas for injection at La Goleta during the summer period.

3. Install additional injection facilities at La Goleta so as to increase the injection capacity of the plant from 30 to 65 million cu. ft. per day.

4. Install dehydration facilities at La Goleta for removal of water from gas prior to its being delivered into the high pressure pipeline facilities.

5. Drill two aditional wells in the La Goleta field in order to provide sufficient withdrawal and injection capacity.

The proposed pipe line from La Goleta to Ventura was to be installed by Southern Counties Gas Company, and was planned as a 16-in. line to operate at 1000 lb. per sq. in. gage. The line from Ventura to Los Angeles was an 18-in. line, which was designed to operate at a maximum pressure of 783 lb. per sq. in. gage. The lines were planned to operate at these higher pressures in order that the field pressure at La Goleta could be utilized and the gas transported from La Goleta to Los Angeles without compression.

The installation of a dehydration plant was necessary, inasmuch as the original pipe line from the field operated at a maximum pressure of 460 lb. per sq. in. gage and condensate could be removed by cooling the gas through expansion from field pressure down to 460 lb. per sq. in. gage. With the proposed pipe line facilities operating at 1000 lb. per sq. in. gage, there was not sufficient expansion from field pressure to provide enough cooling to remove the water. In addition to this, considerable difficulty had been experienced in maintaining accurate control over the cooling in order not to cool to a point where gas hydrates would form.

To provide the facilities to meet the required injection capacity of 65 million cu. ft., Pacific Lighting Corporation installed three additional 600 hp. units. These units along with those in the original plant resulted in the plant having a total of 4700 hp. The three new units were installed so as to operate with an intake from the new 1000-lb. line, thereby utilizing this line to its fullest efficiency.

Two new wells to be drilled were situated with respect to the existing wells so as to provide as uniform spacing on the structure as possible. A portion of the ground surface in the field area is at present occupied by the Marine Air Corps base. Inasmuch as the proposed location of the wells came within the air strip, it was necessary to off-set the well derricks approximately 1500 ft. and slant drill by means of whip-stocking to the desired bottom hole location. Standard drilling procedures were followed in the drilling of the wells down to the top of the structure. Upon reaching the top of the structure 8⅝-in. cas-

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* The housing supports the drive shaft, which is mounted on a main bearing in the housing and a pilot bearing in the engine flywheel. The clutch is mounted on the drive shaft, which is extended to serve as the output shaft for the external drive, and may carry a pulley, gear, sprocket, or drive direct — through a coupling.

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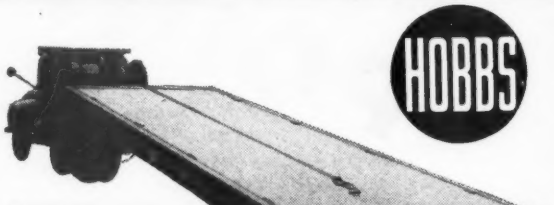

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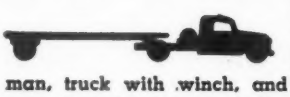

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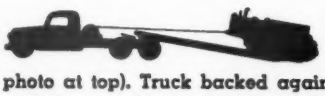

Trailer front is lowered by winch, forming easy-grade ramp (see photo at top). Truck backed against rear of trailer. Load pulled on with winch or moved on under own power.

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ing was set and cemented in place. Following the installation of the 8⅝-in. casing, the wells were drilled ahead into the formation sand. Drilling in the structure was planned so that the drilling mud stood in the hole as short a time as possible, in order to eliminate sealing the sand with mud.

The first well, Miller No. 1, encountered 400 ft. of very coarse sand, and the second well, Miller No. 2, was completed in 300 ft. of finer sand. Following drilling through the sand an electrolog was run on each well and the extent and location of liner perforations were determined from these logs after which the 6⅝-in. perforated liner was hung. Two-inch tubing was then hung in the well to within 25 ft. of the bottom, in order to remove any liquids that might accumulate in the well. The wells were then brought into production and produced open until they had cleaned up.

Production tests were run on each of the wells before connecting them into the field system. Miller No. 1 produced at rate of 145.4 million cu. ft. of gas per day through the casing and Miller No. 2 produced at a rate of 128.1 million cu. ft. per day. The production rate on Miller No. 1 of 145.4 million cu. ft., is the highest rate of gas production for a single well under control in the State of California as far as is known.

Our experience in operating the field as a gas storage field during the past four years has revealed many interesting facts. Continuous pressure checks are made on the various wells in the field by the means of dead weight testers. These pressures, along with the volumes of gas injected and withdrawn, show that approximately 30 million cu. ft. of gas is required to change the pressure in the structure one pound within our present operating range. During the past year the highest pressure reached was 1765 lb. per sq. in gage well head, some 50 lb. per sq. in gage above original pressure.

Reducing the pressure of the structure below the original structural pressure results in a loss in reservoir capacity, which is assumed to be attributed to water encroachment. Calculations show this loss to be at an average rate of one-half of one per cent per year per 100-lb. pressure below the original structural pressure. To date this accumulated loss of reservoir capacity equals approximately 7.82 per cent. Inasmuch as continuing operations of the structure below the original structural pressure would have resulted in serious loss in reservoir capacity, our first objective was to inject sufficient gas to restore the original structural pressure.

In order to prevent further water encroachment plans call for operating the structure so that the average structural pressure will not be below the original well head pressure of 1705 lb. per sq. in. gage. However, it is difficult to predict the action of the structure when increasing the pressure above the original structural pressure. This year we expect to increase the structural pressure approximately 100 lb. above the original pressure and observe the results.

Future plans call for injecting and withdrawing 10,000 million cu. ft. per year. Such a cycle will result in a pressure fluctuation in the structure of approximately 300 lb. Assuming that the edge water can be displaced by increasing the pressure above the original pressure at the same rate at which encroachment took place when pressures were below the original pressure, then it would be necessary to increase the pressure to approximately 150 lb. above the original pressure.

The use of underground storage for natural gas is not new, as there are fields in the United States where this operation has been carried on as far back as 1915. In the last few years, however, there has been a decided increase in the number of fields utilized for this means of conserving gas and equating loads.

E. G. Dahlgren, of the Interstate Oil Compact Commission, reported in 1944 that there were more than 55 storage projects in operation in the United States, with a total withdrawal capacity of some 750 million cu. ft. per day. In 1945, the number of storage projects had increased to more than 65. It is hoped that sufficient gas storage projects will be placed in operation in the United States so as to conserve as much as possible of our natural gas. ★★★

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DUAL FUEL ENGINE

THE need for an internal-combustion engine capable of operating on either gas or oil fuel or a mixture of both has long been recognized. A new dual fuel engine has been announced by Worthington Pump and Machinery Corporation to fill this need. The engine is able to burn as fuel either gas or oil, or any mixture of both. Regardless of the fuel being used, the engine operates on the highly efficient diesel cycle.

The simplicity and safety of the Worthington dual fuel system is evidenced by the fact that it is not necessary to provide fuel gas to the engine at high pressures. The system is capable of operation using fuel gas at pressures as low as 2 in. of water.

Conversion from one fuel to the other, or adjustment of the mixture of fuels, is accomplished by one revolution of a single control wheel.

● **Simplicity of operation.** When operating as a gas engine, the system employs pilot oil ignition. This pilot fuel can be used in amounts as low as 5 per cent of the total full load B.t.u. requirements of the engine. The fuel mixture can be varied to use any proportion of oil and gas from 5 per cent oil and 95 per cent gas to operation on fuel oil only. This mixture may be adjusted manually or an automatic adjustment can be provided to vary the mixture as the gas holder level changes or as the fuel gas supply pressure varies.

When operating as a straight gas engine, the governor acts on the gas fuel supply only, the pilot fuel supply remaining constant regardless of load conditions. Approximately one-half of the no-load fuel requirement is supplied by the pilot oil.

● **Flexibility.** As mentioned, the engine can use a mixture of fuels. The rate of gas consumption remains constant and all load fluctuations are provided for by governor action on the fuel oil supply. In applications where the gas supply may not be sufficient for full time operation as a gas engine, or where the gas supply is a variable factor, the system can be arranged so that the governor will call for all the gas available, the remainder of the load being automatically provided for by varying the amount of fuel oil supplied.

● **Instant conversion.** The unit is instantly convertible from gas to oil or oil to gas operation by a single revolution of one control wheel. If the gas supply should fail unexpectedly this conversion is automatically accomplished by the governor action.

With the dual fuel system the conversion is accomplished instantly without shutting down the engine or dropping the load. The speed change is negligible and full speed recovery is accomplished in a matter of seconds only.

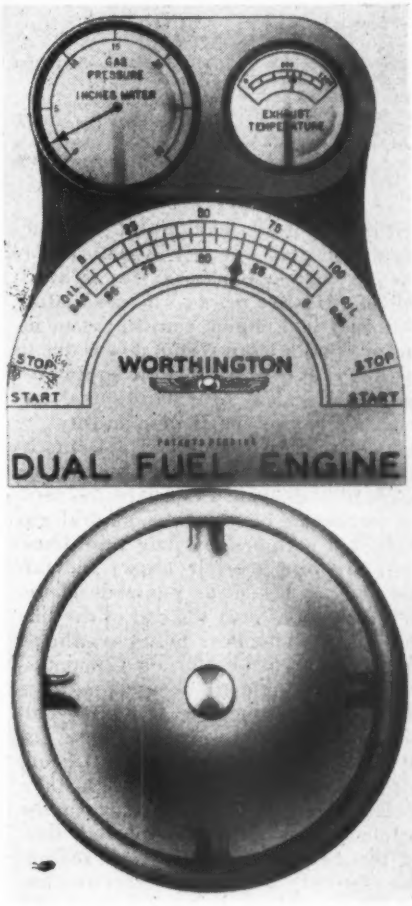
● **Low pressure fuel gas supply.** It is important also to note that the dual fuel system does not require a high pressure fuel gas supply. The system operates with a fuel supply at pressures as low as 2-in. of water.

● **Economy.** The unit operates on the full diesel cycle regardless of the fuel being used and maintains full diesel engine economy whether operating on gas or oil fuel.

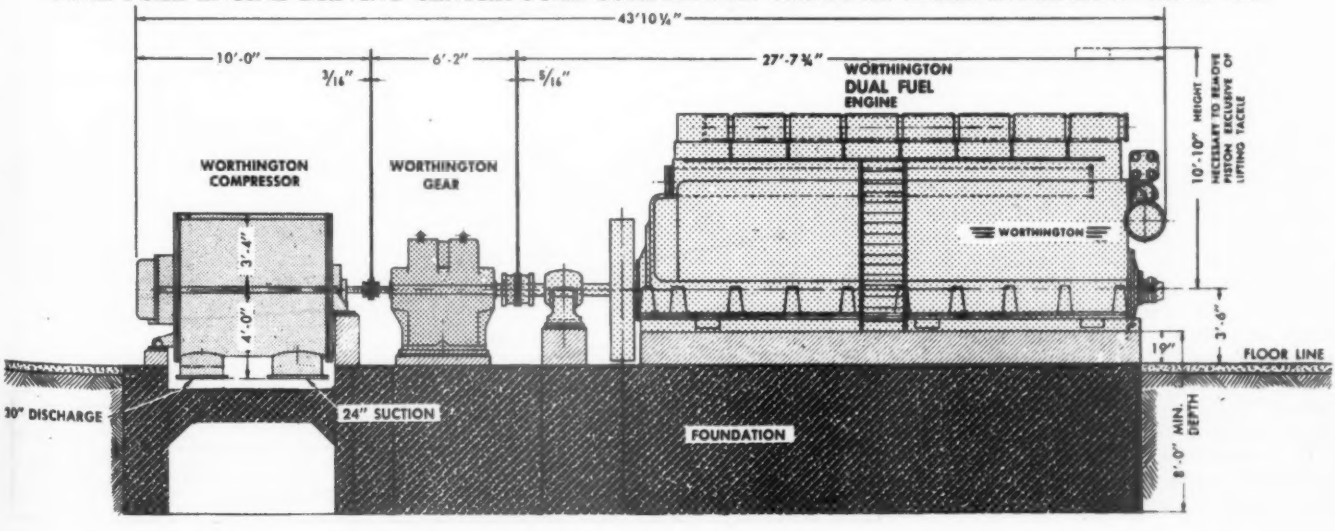
The dual fuel system is applicable to the entire line of Worthington engines covering a range of approximately 150 to 2200 hp. It is applied without any major changes in the original diesel engine.

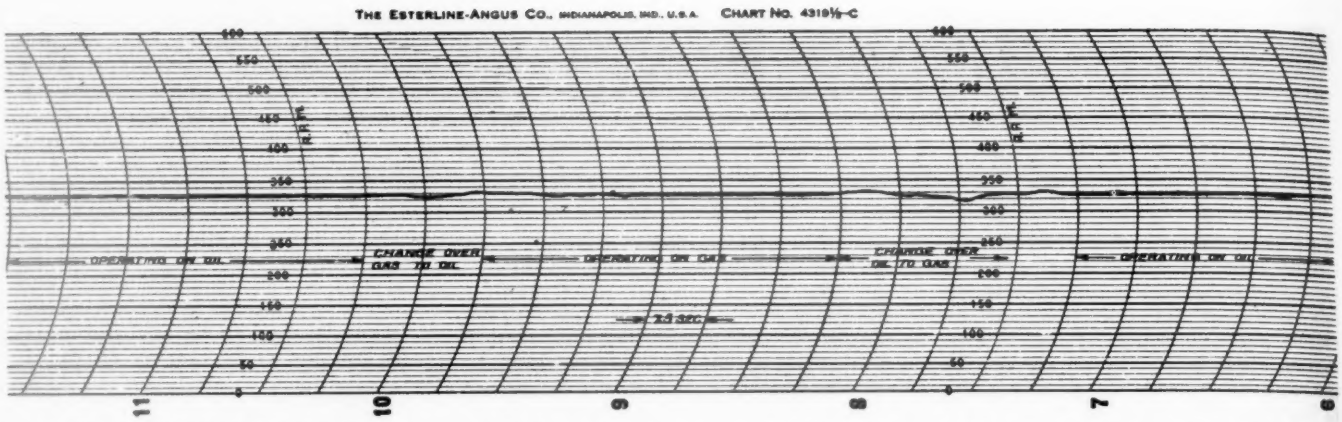
● **Applications.** During the early stages of drilling an oil well, low cost natural gas is often available either from utility service or from the well itself.

During this stage of the operation a dual fuel engine operated on gas provides an economical power supply. After the oil flow from the well is established, the engine may then be operated as an oil engine. Thus, with an initial investment covering one engine, the operator can take full advantage of the most economical fuel available during all stages of the drilling operation. Also, because the equipment used in oil field drilling is usually of a semi-portable nature and is moved from field to field, the same engine can be used on the fuel that is locally available at the lowest cost regardless of location.



DUAL FUEL ENGINE DRIVING CENTRIFUGAL COMPRESSOR THROUGH SPEED-INCREASING GEAR SET





CHECK OF ENGINE SPEED WITH ESTERLINE RECORDING TACHOMETER

Engine—500 hp., 16x20, 4-cylinder dual fuel.
Rated speed—327 r.p.m.
Test load—500 hp. (full load).
Chart speed — 6 in. per min.

Total variation in engine speed:

A. Changing from oil to gas 15 r.p.m.—4.60%

B. Changing from gas to oil 6 r.p.m.—1.84%

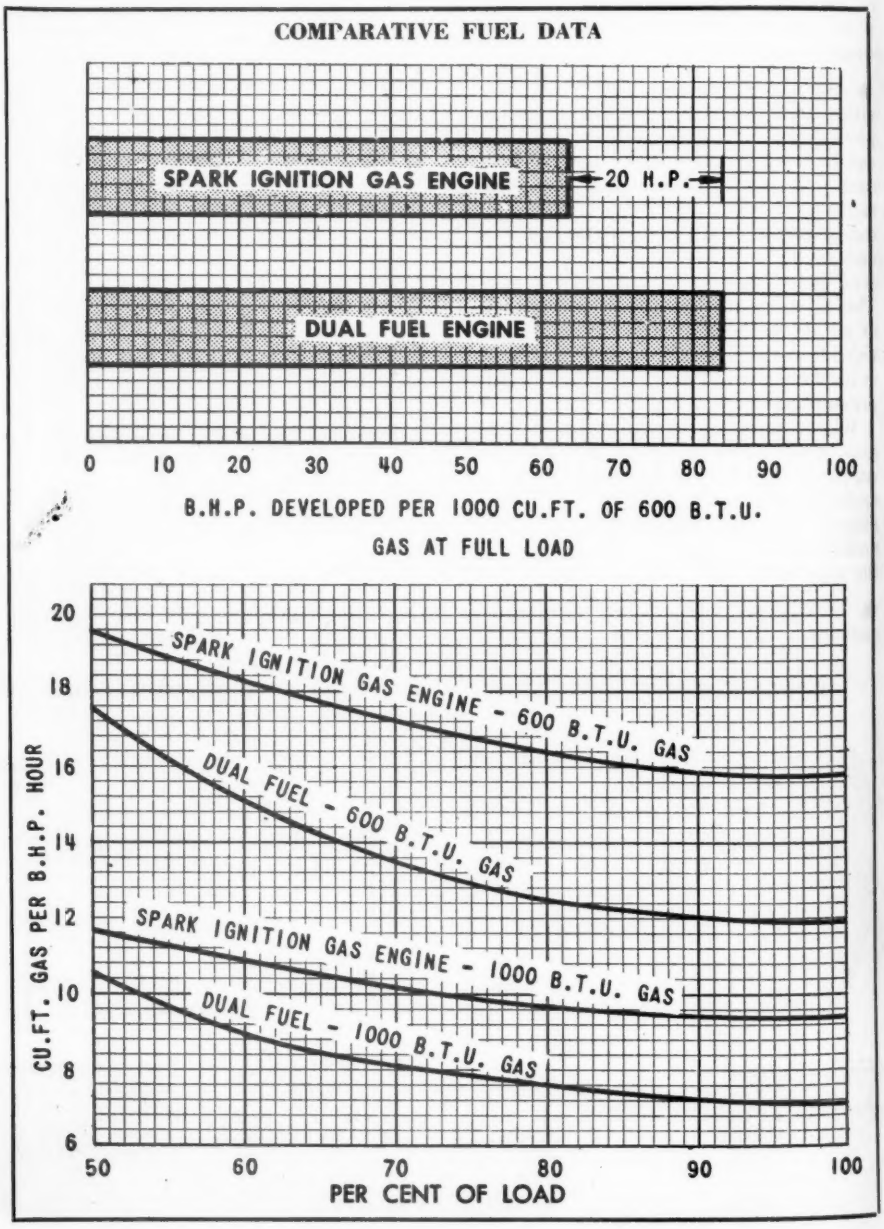
It is often desirable to install dual fuel engines in plants served by natural gas lines even though natural gas is available at attractive prices. The installation of a dual fuel engine constitutes an insurance policy against shut downs due to gas line failure or against the supply being curtailed due to exhaustion of gas fields serving any particular locality.

A particularly broad field presents itself with the use of the dual fuel engine as a load builder for gas companies serving territories remote from natural gas fields, but supplied by long pipe lines. Costs are progressively higher the farther the gas has to be pumped. Therefore, companies near the end of the line find it is uneconomical, not to say almost impossible, to make a firm a 12 months' rate low enough to compete with a straight diesel oil engine. It is almost always possible, however, to make a gas rate that will result in a fuel cost equal to or lower than that possible with a straight diesel oil engine, *provided* the customer agrees to use this gas only during the gas company's off-peak season. This is usually during the warm weather months, roughly from April through October, when house heating is a minimum. With the dual fuel engine the customer can operate on gas as long as his contract period states and then switch to fuel oil during the cold weather months, thus the gas company benefits by increased load during the time it can use it to the best advantage, and the customer gains by lowest annual fuel costs.

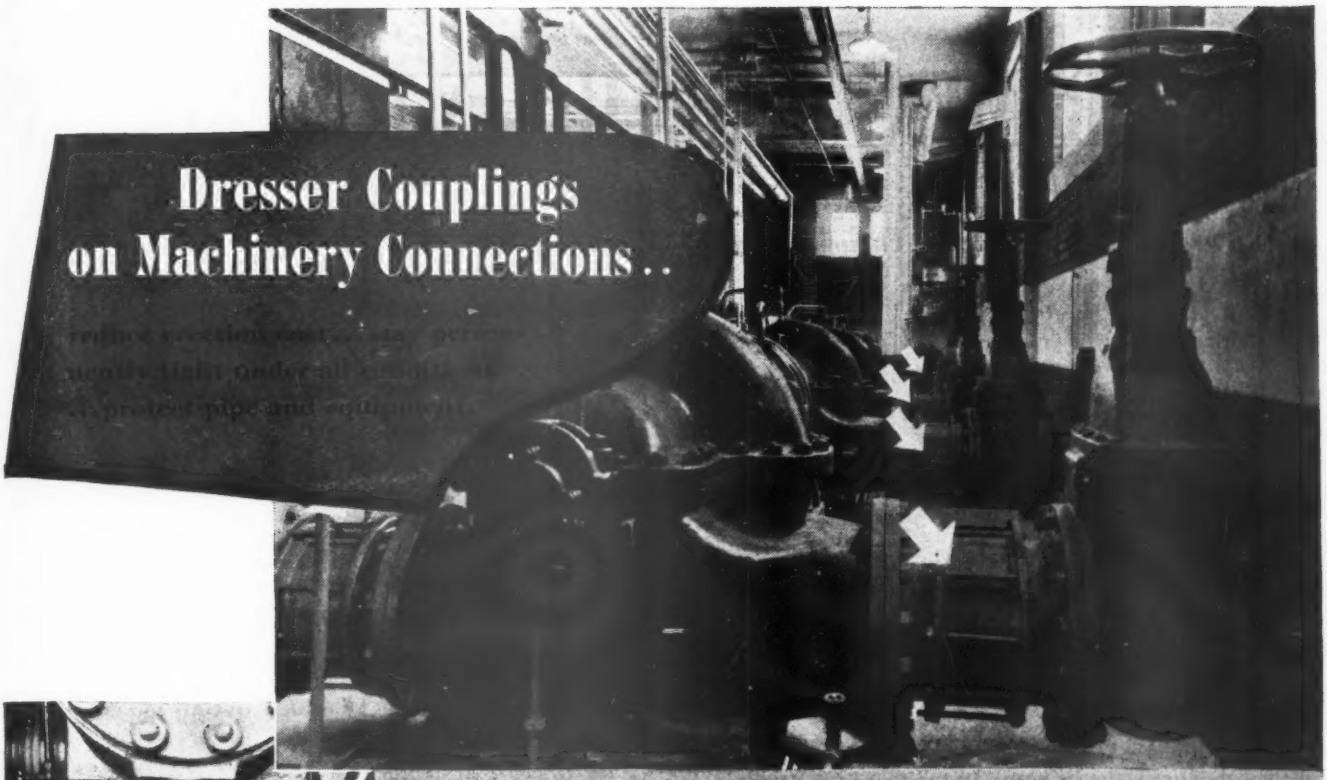
The same reasoning can be applied to gas companies that have interruptable gas rates where customers are served on a continuous basis the year around at a low rate, but with the reservation that the supply can be interrupted upon short notices in emergencies. A simple changeover method to fuel oil enables this customer to qualify for the low gas rate without the hazard of interrupting his power supply.

In refinery operations it is often desirable to provide some use for refinery gases produced as by-products of refining and cracking processes. Gas engines are, of course, the logical solution to this problem. During initial starting, however, and at times during the process cycle there may not be sufficient gas available to operate all the gas engine capacity that would normally be installed. In a case of this kind the dual fuel engine provides a solution.

In certain localities it may also be desirable to refine further the gas produced as a means of obtaining marketable petroleum products, thus reducing the amount of fuel gas for engine operation. Here again the supply of fuel gas is supplemented by fuel oil thus enabling the refinery operator to maintain the most favorable economic balance for his operations under all operating and market conditions. ★★★


COMPARATIVE FUEL DATA
SPARK IGNITION GAS ENGINE
20 H.P.
DUAL FUEL ENGINE
0 10 20 30 40 50 60 70 80 90 100
B.H.P. DEVELOPED PER 1000 CU.FT. OF 600 B.T.U. GAS AT FULL LOAD
CU.FT. GAS PER B.H.P. HOUR
20 18 16 14 12 10 8 6
SPARK IGNITION GAS ENGINE - 600 B.T.U. GAS
DUAL FUEL - 600 B.T.U. GAS
SPARK IGNITION GAS ENGINE - 1000 B.T.U. GAS
DUAL FUEL - 1000 B.T.U. GAS
50 60 70 80 90 100
PER CENT OF LOAD

Dresser Couplings on Machinery Connections..



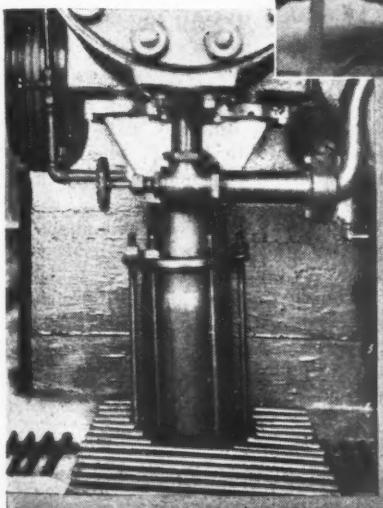


Fig. 1—(Above) Centrifugal pump connections with flexible Dresser Style 38 Couplings.

Fig. 2—(Left) Hot engine connection with Style 40 Dresser Long Sleeve equipped with asbestos gaskets.

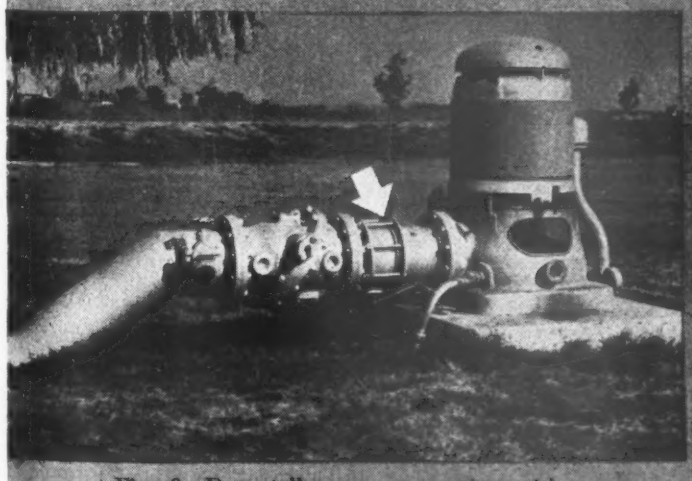


Fig. 3—Deep-well pump connection with flexible Dresser Style 38 Coupling.

Fig. 4—Heavy-duty pump connection with flexible Dresser Style 38 Coupling.

C O U P L I N G S

FOR PLAIN-END PIPE

MEASUREMENT OF SOLIDS IN TCC PROCESS*

A. E. KELLEY

Process Engineer, Union Oil Company of California

THE thermofor catalytic cracking process (TCC) is one of several processes for catalytically processing hydrocarbons to produce gasoline. The catalyst, a natural clay or synthetic material in either pellet or bead form, during contact with oil vapors in the reactors becomes covered with coke, which reduces catalyst activity and must be removed to restore catalyst activity. The coke is burned off the incombustible catalyst with air.

TCC units can be divided into a catalytic section and an oil section, which are integrated in the reactors. The oil section, which handles the hydrocarbons before and after the reactors, contains equipment common to the oil industry, but the catalytic section is novel. In the catalytic section the TCC process solves the problem of coke removal by moving a pelleted or bead catalyst continuously through the reaction and regeneration steps. The purpose of this paper is to discuss the general methods and equipment used in the measuring and establishing of catalyst flow rates, catalyst levels, and reactor seals.

● **General flow.** Fig. 1 is a flow sheet of the catalytic section. Regenerated catalyst from the kiln is carried by a bucket elevator to the reactor hopper located about 70 ft. above the reactors. Gravity causes the catalyst to flow down and through the catalyst pressure legs, the upper seal and distributing pipes, the reactor proper where the oil contacts the catalyst, the bottom seal and distributing plates, and into another bucket elevator, which carries it to the top of the kiln. The coked catalyst then flows by gravity down through the kiln where the coke is burned off with air and thus the cycle is completed.

Fresh catalyst is added, by means of the fresh clay elevator, to a preheater. The hot catalyst then flows by gravity into the kiln feed elevator. To prevent the build-up of catalyst fines in the system, a slip stream of regenerated catalyst is passed down through the elutriator countercurrent to a flow of flue gases. The flow of flue gases is such that it carries fines with it, but allows the catalyst pellets to drop into the top of the kiln over which the elutriator is mounted. Catalyst fines carried out with the flue gases are collected by means of cyclone separators and stored in a fines tank prior to removal from the unit. The hot clay storage tank is used to hold catalyst from the kiln or reactors when it is necessary to work in them. Operating upsets causing high levels in the reactor hopper may also cause a spillage of catalyst into the hot clay tank. The catalyst can then be added back into the system by means of the fresh clay elevator.

*Presented to the Southern California Meter Association, Los Angeles, California, July 16, 1945.

INSTRUMENTATION

● **Flow indicators, F-1.** Accurate catalyst circulation rate is desirable from both a process and operating standpoint and is obtained in this unique system in a simple and efficient manner.

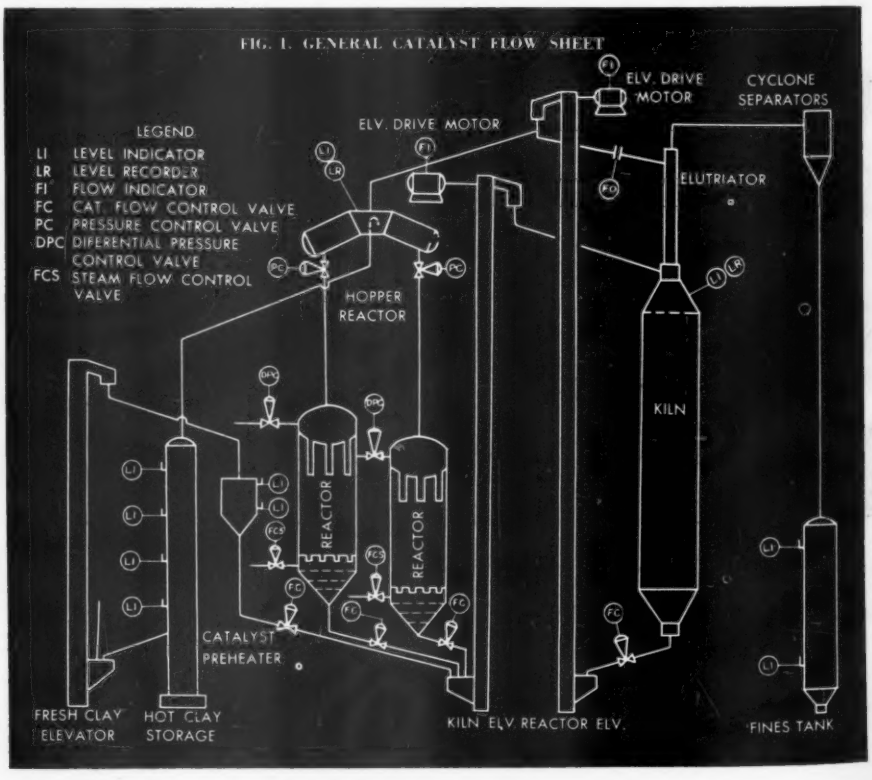
The energy required to run the motors that drive the clay elevators at their constant speed of about 100 ft. per min. is measured by means of a kilowatt meter in the control house. As the load or catalyst weight in the buckets is increased, the motor power requirements increase. Thus to obtain the catalyst circulation rate all that is needed is a correlation between power required to drive the motor and the quantity of catalyst being carried. This calibration is obtained experimentally for each elevator. A typical curve is shown in Fig. 2. The method used in obtaining the curve is as follows:

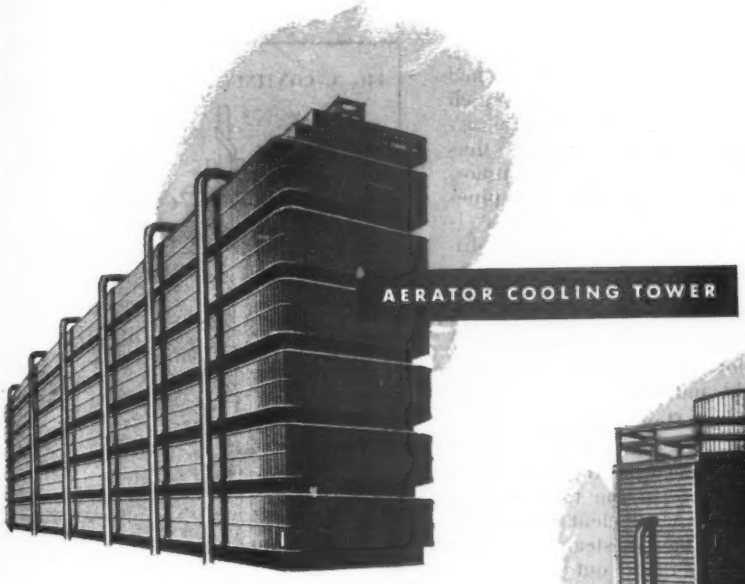
The clay rate is set to the elevator to give a constant power requirement, as indicated by the kilowatt meter, and the circulation is stopped. The content of three of the buckets is then removed and weighed. Assuming all the buckets containing catalyst to be equally loaded, the circulation rate in tons per hour can be easily calculated by multiplying the catalyst weight per bucket by the elevator chain speed in buckets per hour and dividing by 2000, to convert pounds to tons. About three points at different loads will establish the curve. If desired the kilowatt meters in the control house can be marked directly in tons per hour circulation.

● **Flow control valves, FC.** The catalyst flow rates are varied by means of piston-operated butterfly valves in the position shown in Fig. 1. These valves are normally operated remotely from the control house.

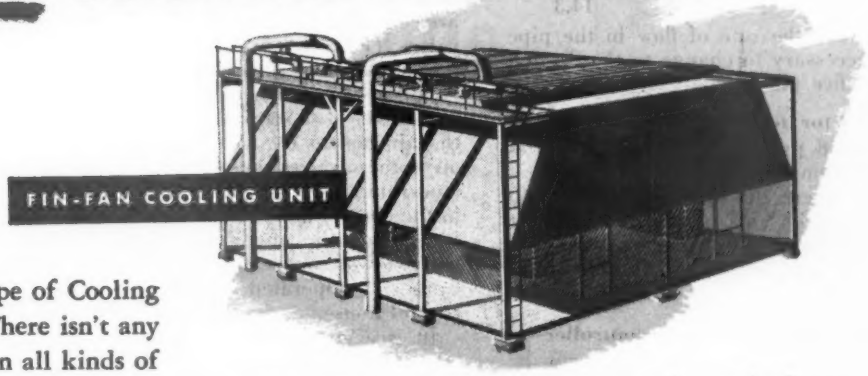
Air pressure is transmitted manually to a valve controller with positioner operating an air piston and is both recorded and indicated in the control house. The pistons movements are translated into movements of the butterfly control valve through a suitable linkage and worm gear arrangement. Also oper-

FIG. 1. GENERAL CATALYST FLOW SHEET





WHAT IS YOUR COOLING PROBLEM?



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3. The FLUOR *Fin-Fan* Cooling Unit for installation where water is scarce or expensive and bottom temperatures desired are not approximately atmospheric temperature. FLUOR recommendations are based upon the correct unit for the specific conditions and requirements, backed by extensive field tests and broad engineering experience on all three types of Cooling Units.

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ated by the piston arm movements are two limit switches. These indicate, through actuation of green and red lights whether the valve is in a closed or partially open position.

If desired, the valves can be operated by hand. To do this, transmitted air to the controller is shut off at the valve and the hand-driven worm gear is engaged. A pointer on the hand driven worm gear shows the degree of opening of the valve.

The units with two reactors depend upon the air loading stations to give continuous indication of the approximate degree of opening of the reactor outlet valves. Thus equal catalyst rates can be maintained through each reactor. Occasionally the rate through each reactor is checked by closing one of the outlet valves and reading the new catalyst rate on the wattmeter.

● **Flow orifices, FO.** In positions such as the elutriator feed line where the catalyst flow rate may be maintained at a constant value for long periods, flow orifice plates are used. These consist of eccentrically drilled plates installed with the hole on the bottom of the pipe cross section. The approximate flow capacity of these plates, when situated in the 45 deg. slope feed line, has been experimentally found to be for both head and pellet as follows:

Size, in.	Rate, T per hr.
2	2
3	6.5
4	14.3

To vary the rate of flow in the pipe it is necessary to change to the desired size orifice plate.

● **Reactor top and bottom seals.** As mentioned previously, the oil and catalyst sections are integrated in the reactors, where the pressure is about 10 lb. per sq. in. and top and bottom inert gas seals are used to prevent oil vapors from escaping out the top and bottom of the reactors.

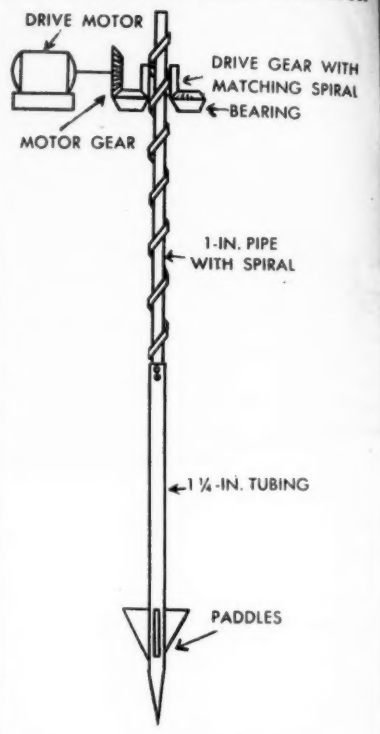
● **Differential pressure controllers—DPC.** A pressure differential can be maintained across a pipe full of catalyst pellets by maintaining a flow of gas through the pellets. As shown in Fig. 1, inert gas is inserted above the dished head in the reactors and about a ten inch water differential is maintained across the seal pipes. Some inert gas thus escapes up the pressure leg to the atmosphere and through distribution pipes into the reactors. If the catalyst is drained from the pressure legs, the differential pressure can no longer be maintained and oil vapor can escape up the leg to the atmosphere. The differential is controlled from the control house and if it falls below a minimum set value, warning light and horn are actuated.

● **Bottom seal flow controllers, FCS.** Again referring to Fig. 1, it is seen that steam is introduced in the bottom of the reactors between the top two distributing plates. A sufficient quantity is used to cause a flow of steam both into the reactor proper and out the bottom catalyst line where it is drawn off at about atmospheric pressure. The rate of sealing steam is controlled from the house and if it falls below a minimum set value a warning light and horn are actuated.

● **Pressure control valves, PC.** The reactor pressure legs are of such length that the head of catalyst is great enough to gravitate the catalyst into the reactors under their normal operating pressures of 10 lb. per sq. in. gage. Surges of pressure could, however, stop this flow and blow the catalyst along with oil vapor back into the hopper. To prevent this from happening, the reactor feed lines are equipped with pressure control valves (P.C.) identical in design with the flow control valves (F.C.) previously discussed. When the reactor pressures exceed a set value a solenoid in the air line to the piston shuts off the air to these valves thus closing them and a warning light and horn are actuated in the control house. When the pressure is reduced the operator can reset the valve to its open position. The valve can also be operated manually from the control house.

In case of the above emergency the catalyst flow into the reactors is stopped. To prevent inadvertent emptying of the reactors, the high pressure switch also operates a solenoid in the air line to the flow control valves (F.C.) on the reactor outlets, thus closing them and stopping the catalyst circulation. This solenoid is reset by the operator along with the high pressure valves.

FIG. 3. CONTINUOUS LEVEL INDICATOR



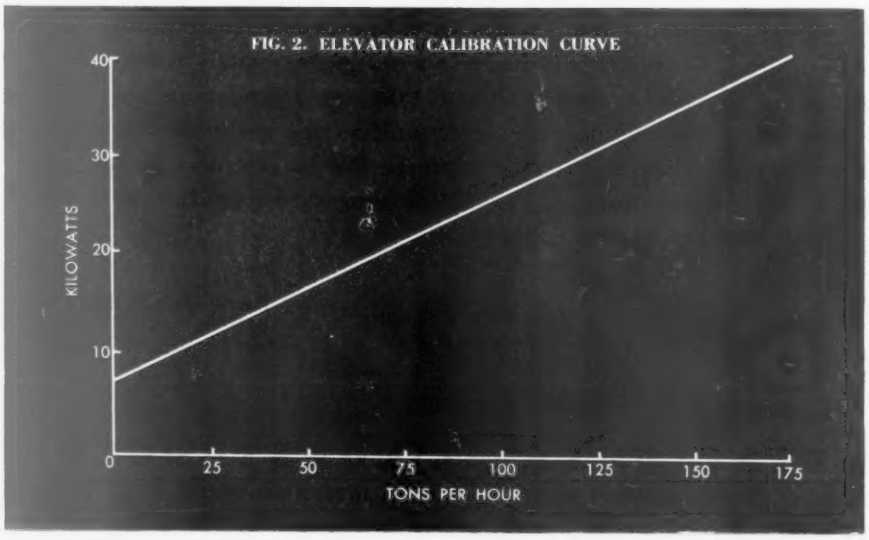
LEVEL INDICATION

● **Hopper indicators, LI — LR.** As shown in Fig. 1, two level indicator-recorders are used, one in the reactor hopper and one in the kiln hopper. Accurate level measurement in the reactor hopper is necessary to prevent overflow of catalyst into the hot clay storage tank at high levels or the loss of top reactor seals caused by draining all the catalyst from the hopper and reactor feed legs. High levels in the kiln hopper must be avoided to prevent filling the catalyst inlet line. When this occurs, the catalyst discharge from the kiln elevator falls down the shaft. If this situation is not rectified soon enough, it is probable that the elevator buckets will either jam in the catalyst partially filling the shaft or be ripped off. Low levels in the kiln hopper may stop the flow of catalyst into the kiln proper, thus upsetting its operation.

A simplified diagram of the level indicators is shown in Fig. 3. The shaft consists of an upper section of 1-in. standard pipe pinioned to a lower section of 1¼-in. tubing. Wrapped spirally around and welded to the upper section of pipe is a ½-in. diameter round bar. Welded to the lower section of tubing about 12 in. from the bottom are 4 triangular sections of metal called paddles. The upper section of pipe rides up and down through a sleeve with a matching spiral and the pipe spiral engages the sleeve spiral. The sleeve sets on a bear-

(Continued on Page 142)

FIG. 2. ELEVATOR CALIBRATION CURVE



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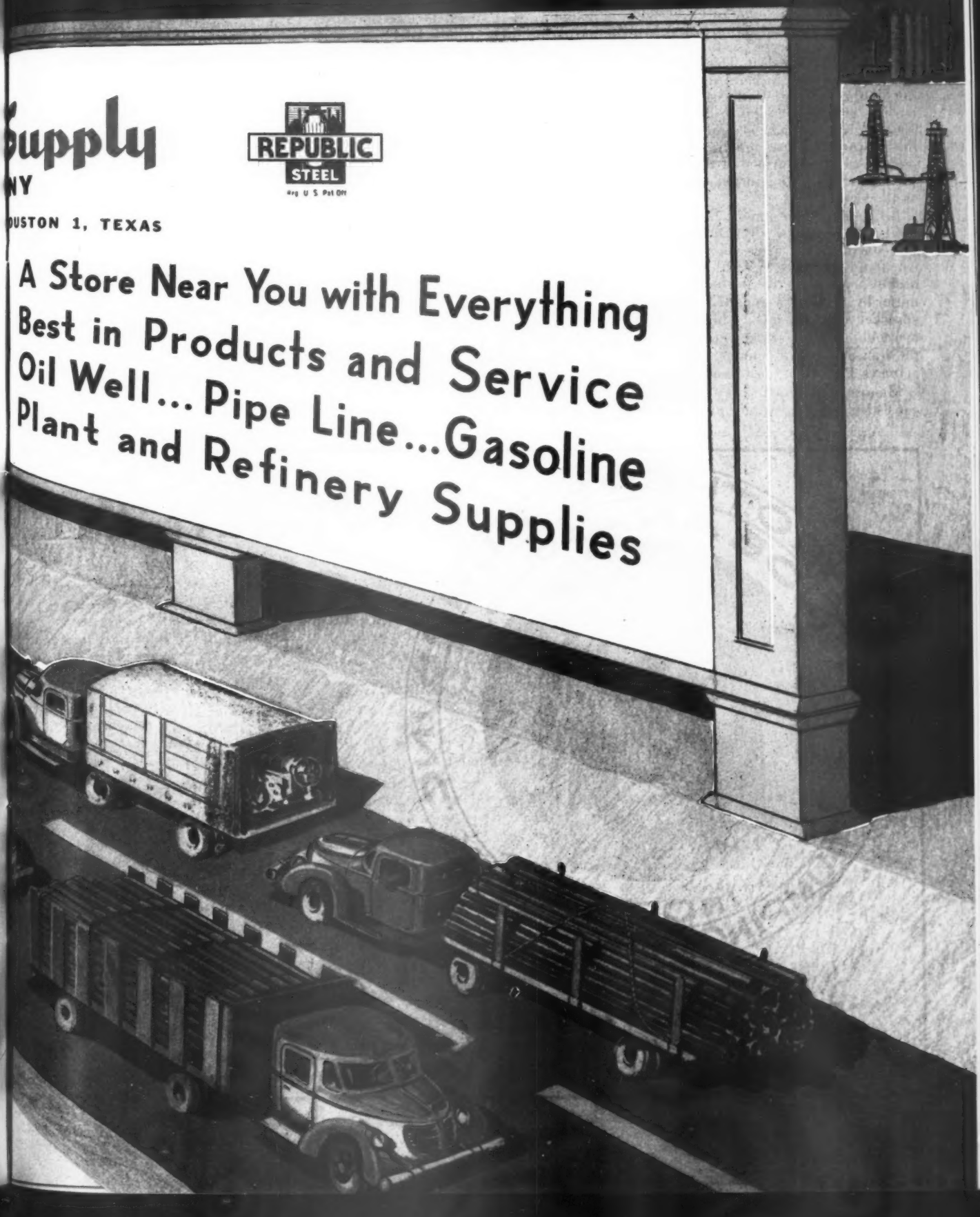

(Continued from Page 138)

ing which prevents its vertical movement, and is rotated at constant speed by means of a motor. The shaft is properly weighted so that gravity causes its movement downward. The purpose of the bottom spearlike point of the shaft is to provide a resistance which will counteract a tendency of the paddles to force the shaft to move in a horizontal plane.

As the paddles came in contact with the catalyst, they tend to slow down the rotation speed of the shaft. The sleeve, which continues to rotate at a constant speed, transmits an upward pressure from its spiral to the section of pipe spiral in contact with it. This forces the shaft and paddles to move upward and out of the catalyst. If the shaft moves too far, gravity causes it to drop again. Finally, a condition is reached when these two forces are equalized and the paddles ride the surface of the catalyst with the shaft moving at the same speed as the sleeve.

Because of their importance, hopper levels are pneumatically transmitted to the control house where they are indicated and recorded. Vertical movements of the shaft actuate the pneumatic transmitter by means of a weighted chain and sprocket arrangement. At high levels a mercoid pressure switch, operating on the transmission air, sounds a horn and actuates a red light in the control house.

Manually operated level indicators, consisting of a piece of pipe with a cone bottom, are used to check the automatic indicators at intervals.

● **Storage tank level indicators — LI.** As shown in Fig. 1, level indicators are placed on the hot clay storage tank, on the catalyst preheater, and in the fines tank. These level indicators are actuated by catalyst pressure and their use differs from the type discussed above, as they only indicate that the level is below, at, or above the point at which they are located. The exact level must be obtained manually. This type of indicator is suited to level measurements in these vessels, as continuous accurate measurement is not necessary.

These indicators consist of a diaphragm, a shaft with one end attached to the diaphragm, one or two switches attached to the other end of the shaft, and a suitable housing. The assembly is mounted over an opening in the side of the vessel so that catalyst can contact the diaphragm.

As the catalyst level rises and contact is made with the diaphragm, a pressure is exerted against it. This pressure increases with the catalyst height and causes the diaphragm and the shaft attached to it to move in the opposite direction. The electrical contacts or switches attached to the shaft are adjusted to make or break control for a given movement of the shaft and thus turn on and off signal lights in the control house. Through the use of more than one of these units an approximate catalyst level can be obtained for very tall vessels.

As an example of their use, the instrumentation of the catalyst preheater will be considered. Two double switch units are mounted on this vessel. These actuate three signal lights located in a vertical row in the control house. The bottom unit contains a normally closed switch in the lower light circuit and a normally open switch in the middle light circuit. The top unit contains a normally closed switch in the middle light circuit in series with the switch discussed above and a normally open switch in the upper light circuit. When the catalyst contacts the lower unit the pressure on the diaphragm operates both switches breaking the lower light circuit and closing the middle light circuit. As the catalyst pressure moves the upper unit diaphragm its switches break the middle light circuit and close the upper light circuit. Thus three approximate catalyst levels have been indicated:

1. The level is below the bottom unit (red light on).

2. The level is between the units (white light on).

3. The level is above the top unit (green light on).

The levels in these vessels are checked manually at intervals. This is done using a steel tape weighted with a plumb bob. The tape is lowered through openings in the top of the vessels and when contact is made with the catalyst, the distance is read on the tape. ★★★

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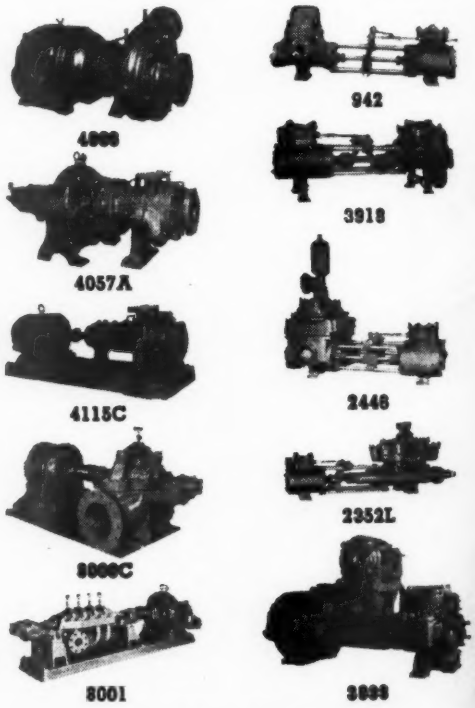

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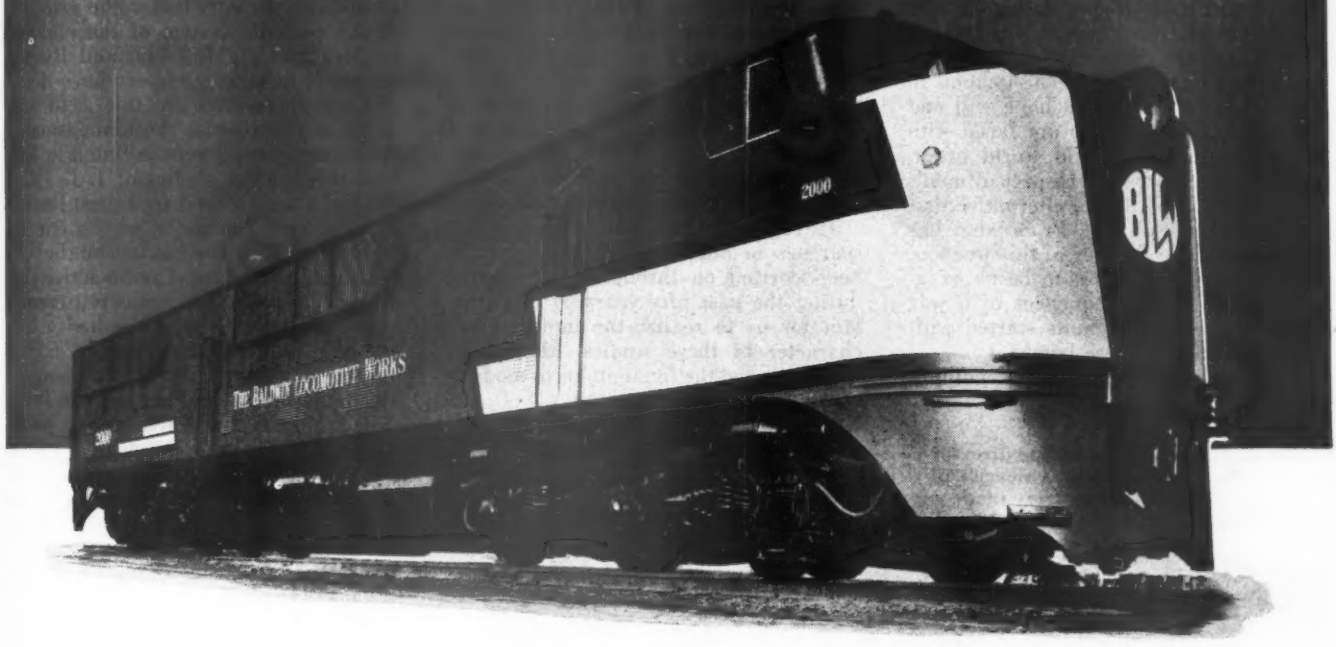

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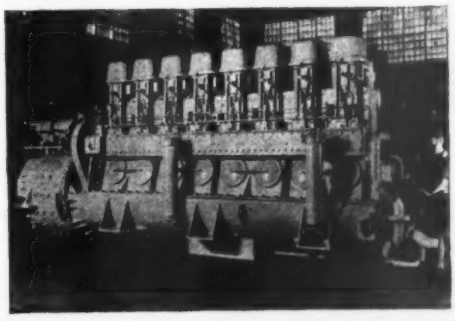

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Atomic Bombs and the Future

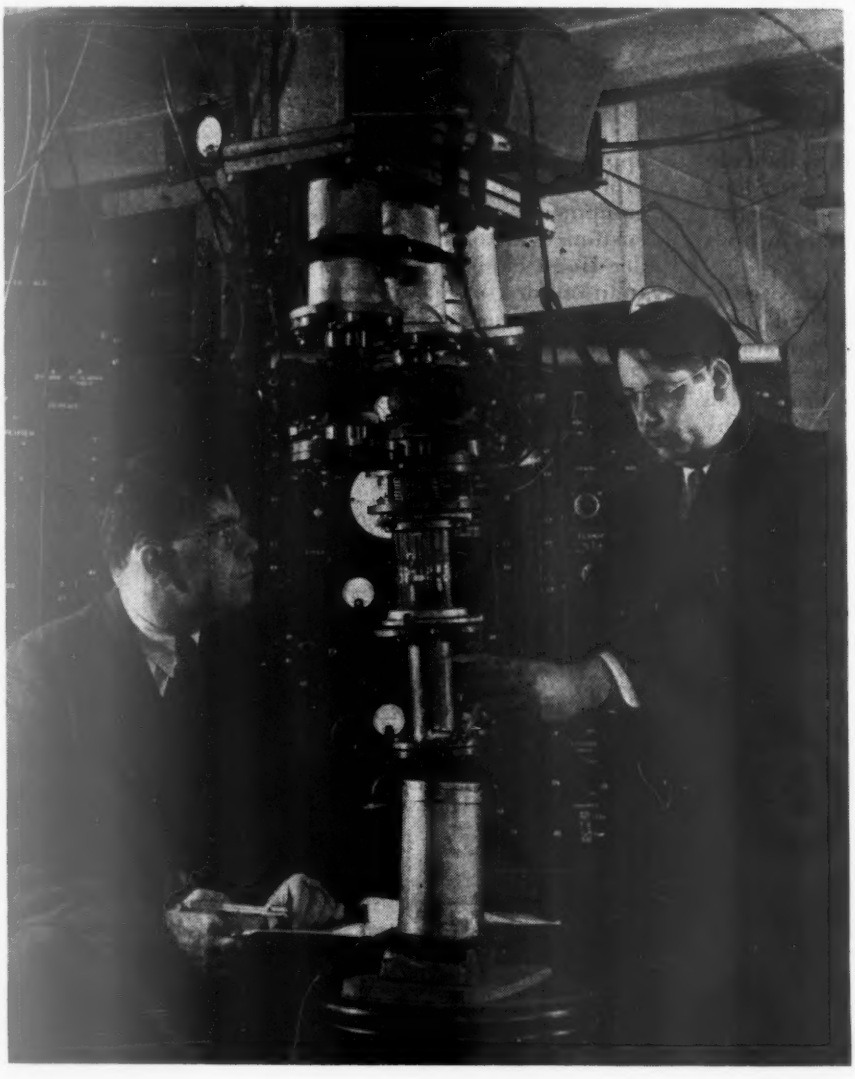
EDWARD U. CONDON
Westinghouse Research Laboratories

EVERYONE today is speculating on what the future of atomic power will be, now that it has been revealed that the atomic bomb is a reality—a potent weapon in our hands, which we all hope will end war among nations. We are faced with the opportunity to build world order, and have the horrible prospect of man's total annihilation as the alternative that confronts us if we fail. From what has been said of the potency of this weapon, total annihilation seems to be no exaggeration of the consequences of a war in which both combatants started with a good supply of these bombs.

It is evident that at present nothing more is to be told of the technical details beyond the sketchy accounts we have been given of the magnitude of the project, of the general nature of the first test in New Mexico, and of the enormous potency of the new weapon. But we all must consider in sober earnestness some of the implications of the existence of this weapon.

It represents a culmination of researches in atomic structure that have been carried on throughout the world during the past fifty years. It is important for us to realize the international character of these studies. More than fifty years ago the foundations of modern atomic science were laid in the discovery of the periodic system of the elements by Mendeleef, a Russian, and Russian scientists in large numbers have distinguished themselves in this field ever since. In the nineties the foundations of electronic science were initiated in England through the studies of J. J. Thomson and a decade later by Ernest Rutherford, a New Zealander who pioneered in understanding the fundamental nature of radium and natural radio-activity. In the early period France was represented by Madame Curie, who has had a long line of distinguished successors, including her daughter, Irene Curie, and her distinguished husband, F. Curie-Joliot, who, I am told, secretly carried on researches on atomic power during the German occupation of France. There is not space here to give names; in the modern period since 1930 progress in this field has been made by Russians, Americans, English, Danes, Germans, Italians, Japanese, and others.

Dr. E. U. Condon, associate director, Westinghouse Research Laboratories, left, and Dr. Jerald E. Hill, research physicist, at the target end of a 90-ton atom smasher. Early discoveries made on this first industrial atom-smasher, built in 1937, contributed to the knowledge that made the atomic bomb possible.



We in America have done some fine work in this field of which we have a right to feel proud. We have a right to feel proud in the spirit that we have been able to play a part in developing man's growing mastery over the forces of nature, and in the faith that by us this weapon will be used righteously in the preservation and further development of freedom everywhere. But we have no right to feel the slightest tinge of prideful superiority over the scientists of other nations who have contributed so much to the background science of the atomic bomb.

Although there is a natural continuity about all scientific development, the decisive discovery that made the atomic bomb possible was made in late 1938 in Germany. It was not made by persons working with military objectives in view. It was made by persons who were engaged in fundamental research in physics and who were working in the spirit of free international collaboration that has characterized scientific progress in the modern period. The implications of the discovery were soon realized by physicists throughout the world, but with the coming of war it became an important matter of national policy in each of the countries that the work in this field be greatly speeded up and that it be carried on under great secrecy.

The basic discovery was made in Germany, and the basic scientific facts were disseminated throughout the world before wartime secrecy policies were established. Therefore, although we may not know in detail what is going on else-

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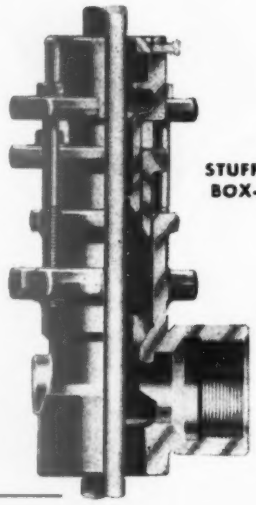

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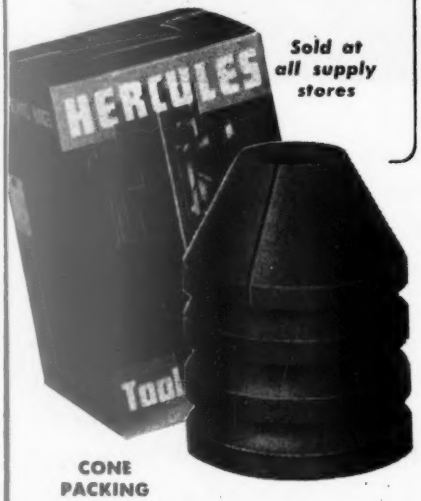

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where, we know that the scientists of every country had at the outset an equal access to the basic facts. In Germany, in France, in Italy, in Russia, in Japan, in England, in America—anywhere there are physicists in laboratories it was possible for this work to go ahead.

This was a big job, however, and it took many men and vast industrial resources as well as basic scientific knowledge and understanding. The Anglo-American coalition has done it first and that is important and was of immediate great value in ending the war. We not only know how, but we have plant capacity and can produce atomic bombs. It is a great achievement scientifically and a great achievement industrially. It is almost inconceivable that so much has been accomplished since January, 1942, when the large program was launched.

But before we get too prideful about that, let us reflect that we do not know yet how near the Germans came to getting there first nor do we know what progress the Japanese made.

We cannot assume for a moment that we will have an Anglo-American world monopoly on the use of atomic energy for more than a few years at the most. But even let us suppose that no one had hitherto started this work besides the Anglo-American coalition and the Germans, who are now under our control. We accomplished this in less than three years at a cost of approximately two billion dollars. There is no denying that we have many first-rate physicists and a marvelous industry — just the right combination for this job. However, the other side of the picture is this: what we can do in three years, others can do in perhaps five or six years, especially with the knowledge, which everyone now has, that it is not a gamble but surely can be done. As to the cost of two billion dollars, it must be remembered that only a small part of the figure represents research costs, the rest went for industrial plants for making the bombs. And it also must be remembered that the costs are high because of the inevitable waste associated with extreme urgency. For example, much money was spent following up simultaneously several alternative lines of investigation when, under peacetime conditions, only one at a time would be followed and solutions found without the expense of developing all the alternatives.

Finally it must be remembered that two billion dollars is not a very great sum of money in terms of budgets of major powers. It is, for example, considerably less than the loss to American investors on defaulted German bonds that were floated between World War I and World War II. It is moreover less than 2 per cent of the national annual income when we operate our industrial plant at a maximum capacity as we have been doing in recent years.

I am not advocating that, therefore, we should freely tell all the technical results of our program. I am making the point that we cannot assume that we shall have the military advantage of exclusive possession of this weapon for more than a few years. We must not develop a Maginot Line mentality in which the atomic bomb is our Maginot Line.

Returning to the question of the cost, there is another point that is even more important than those already made. It cost us two billion dollars to do the job the way in which we did it. And here I am not referring to the costs of multiple solutions of some problems nor of the costs of rush construction under war conditions as compared with more economical peacetime methods. I am rather referring to the fact that we do not know very much about this subject yet. We did the job in the way we saw we could, with emphasis on speed and without regard to cost.

There may be vastly simpler ways of doing this than we have used. Already, I suspect, a large part of the plants we have built are obsolete. We know so little about this subject that we do not know for sure that the making of atomic bombs requires the vast industrial plants we have erected for the purpose.

It is conceivable, for example, that in the years to come some small group of Nazi scientists working in some remote haven, say in South America or perhaps in Spain, may find a way to do this thing with only small, inexpensive, and inconspicuous equipment. That is one of the most important reasons why we must continue the most careful and thorough investigation of atomic physics and why we must set up a world order that really covers the entire world—one that does not leave us unaware of what is going on in any remote valley in Spain. With this power in man's hands, world cooperation must come. It is peace or death.

Let us recapitulate:

(a) Man is now in possession of a new kind of energy source vastly more powerful than anything used before.

(b) The atom bomb is the culmination of a war effort, built on decades of free international exchange of scientific knowledge.

(c) While we produced the atomic bomb first, other national groups working independently may not be far behind right now.

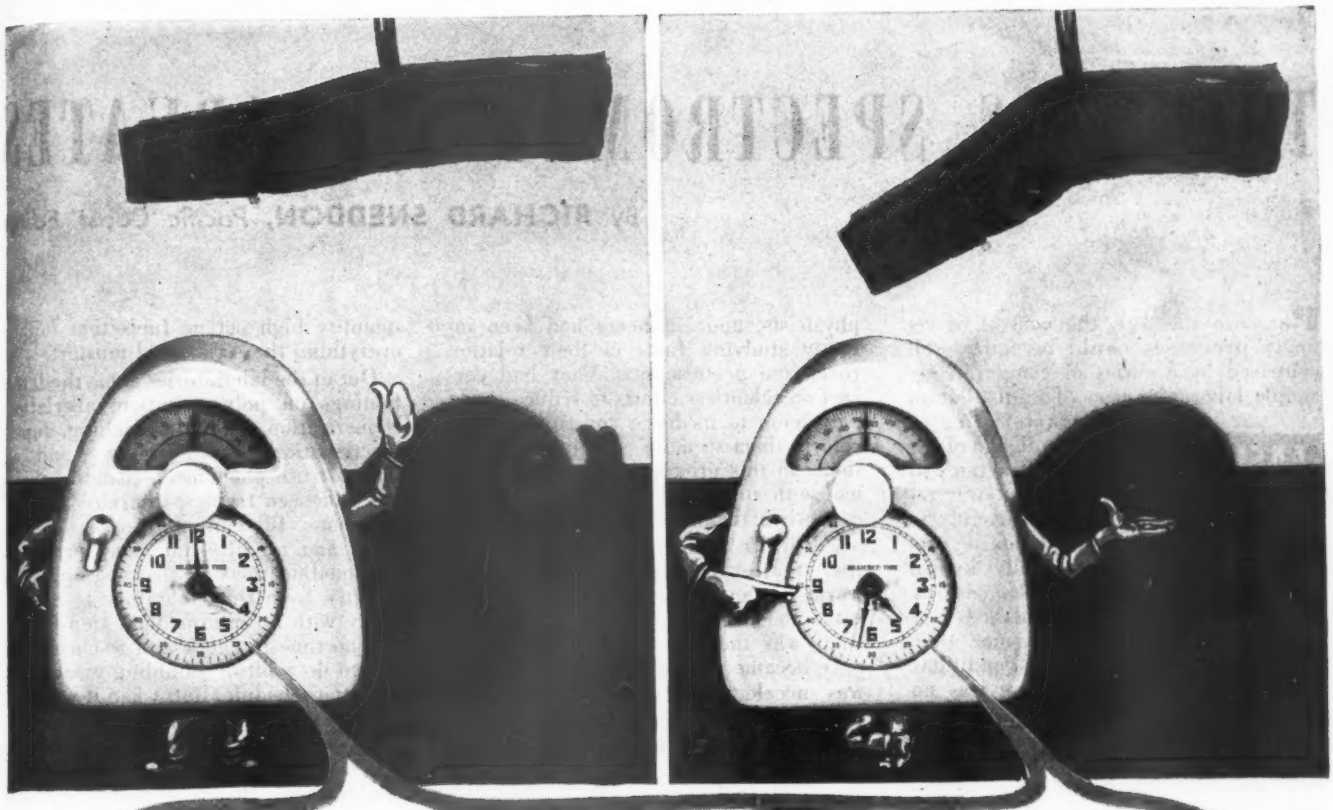
(d) It is a certainty that, spurred by the knowledge that the thing can be done, any major national group could, without aid from us, and without benefit of espionage, at least do what we have done within a few years.

(e) Our knowledge of this field is very incomplete and it may be possible to do what we have done in vastly simpler ways than the only way known to us at present.

Therefore,

(1) We must set up a world order including all peoples to make certain that atomic power is used only for peaceful purposes, and

(2) We must continue intensive cultivation of fundamental research in atomic physics to the end that we may really know all about this tremendous new source of power so that we may apply it to useful purposes in the years of peace that lie before us. ★★★



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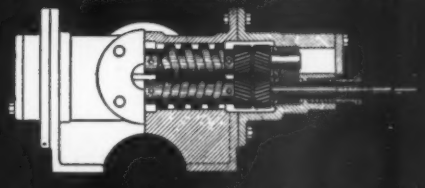

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THE MASS SPECTROMETER GRADUATES

By **RICHARD SNEDDON,** *Pacific Coast Editor*

EXCLUSIVE

PRIOR to the war, the control of refinery processes could be fairly well contrived by a series of comparatively simple laboratory tests. The distillation characteristics of crude oil, and of the various fractions in to which it was resolved in refining practice, could be quickly determined by standard procedures that were universally known and easily applied. In addition, during the prewar period, refining methods had been reasonably static for some time and behavior under normal conditions of operation, so long as there was no drastic change in feed quality, could be fairly well predicted.

When Hitler overran Europe, however, and cast his beady eyes on the rest of the world, the situation underwent a decided change. It became immediately obvious that the war in all its phases—land, sea and air—was to be decided by mechanisms as much as men. This precipitated a mad scramble for the balance of power, which, coincidentally involves the edge in fuel quality and quantity.

Fortunately, for many years before the actual outbreak of war, chemists, physicists, and engineers had been intently studying fuels in their relation to engine performance. They had carried on relentless efforts to reduce crude petroleum to its basic constituents and reform them in more effective combinations. In this program they had already met with an encouraging degree of success when the war came.

Forthwith there was launched one of the greatest conversion programs the world has ever known. The petroleum research that had been proceeding at what was thought to be a pretty fast pace became so vitally important that it was accelerated tremendously. Airpower supremacy, conceded to be the prime requisite of military success was dependent on two factors, engine design and fuel quality. The petroleum industry was determined that lack of adequate fuel would not be the obstacle to ultimate victory, and as our enemies well know, it wasn't long before the oil industry was producing in prodigious quantity high octane fuels that topped everything the Axis could muster.

Out of the laboratories came the latest findings on polymerization, alkylation, isomerization, catalytic cracking, superfractionation, hydroforming — and all the abstruse phenomena that the chemists had been trying to harness to their ambitions. Pilot plants were built, torn apart and rebuilt—but many processes and modifications of processes jumped directly from the laboratory to the refinery with no intermediate step. There was no time to check and re-check. We had to do a bit of gambling in order to meet the schedule. But, when it was necessary we gambled—and we won!

These new methods of manufacture called for new methods of control. Particularly was this true in the analysis of the complex gas mixtures that were involved in catalytic cracking and, indeed, in virtually all the modern high octane fuel producing systems. The common laboratory distillation method had one distinct disadvantage — it was not fast enough to be utilized for the checking of certain important phases of these refining methods. It was also incapable of complete separation of fractions having nearly equal boiling points. However, it was, and still is, an essential process in the laboratory fractionation of mixed hydrocarbons of higher molecular weights.

To solve the problem of analysing the mixed gases and lighter hydrocarbons, about this time a new "mass spectrometer" appeared on the petrolic horizon. This ingenious device was also the culmination of long and persistent research in that branch of sub-atomic physics, popularly known as "electronics." A number of elements were known to contain two or more different types of atom. These were designated as "isotopes." They were not distinguishable by any ordinary analytical scheme, but had been studied for many years with the aid of a mass spectrometer. It was a new version of this machine that was developed by Consolidated Engineering Corporation of Pasadena, California, first, for the analysis of soil gases, but later as a gas analyser for the control of modern refinery processes. By the time the need for a speedy analytical method for mixed gases had become really urgent, Consolidated physicists had already proved, to themselves at least, that the mass spectrometer was the answer.

The remarkable method by which this unique device automatically ionizes the molecules in complex gas mixtures and then segregates them in individual

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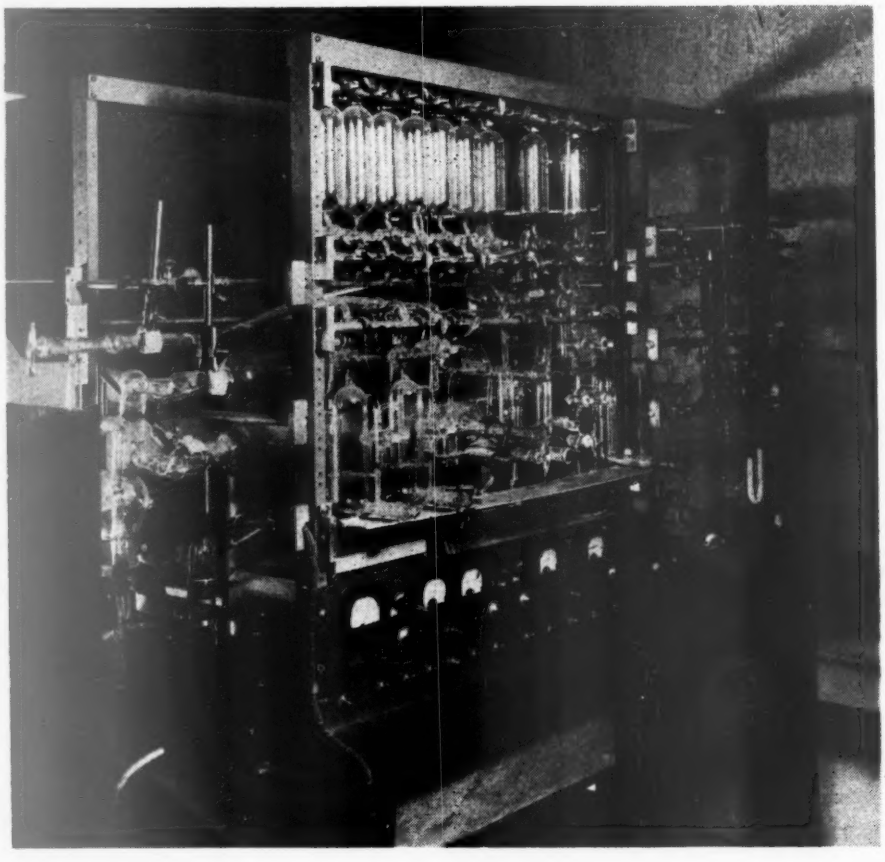
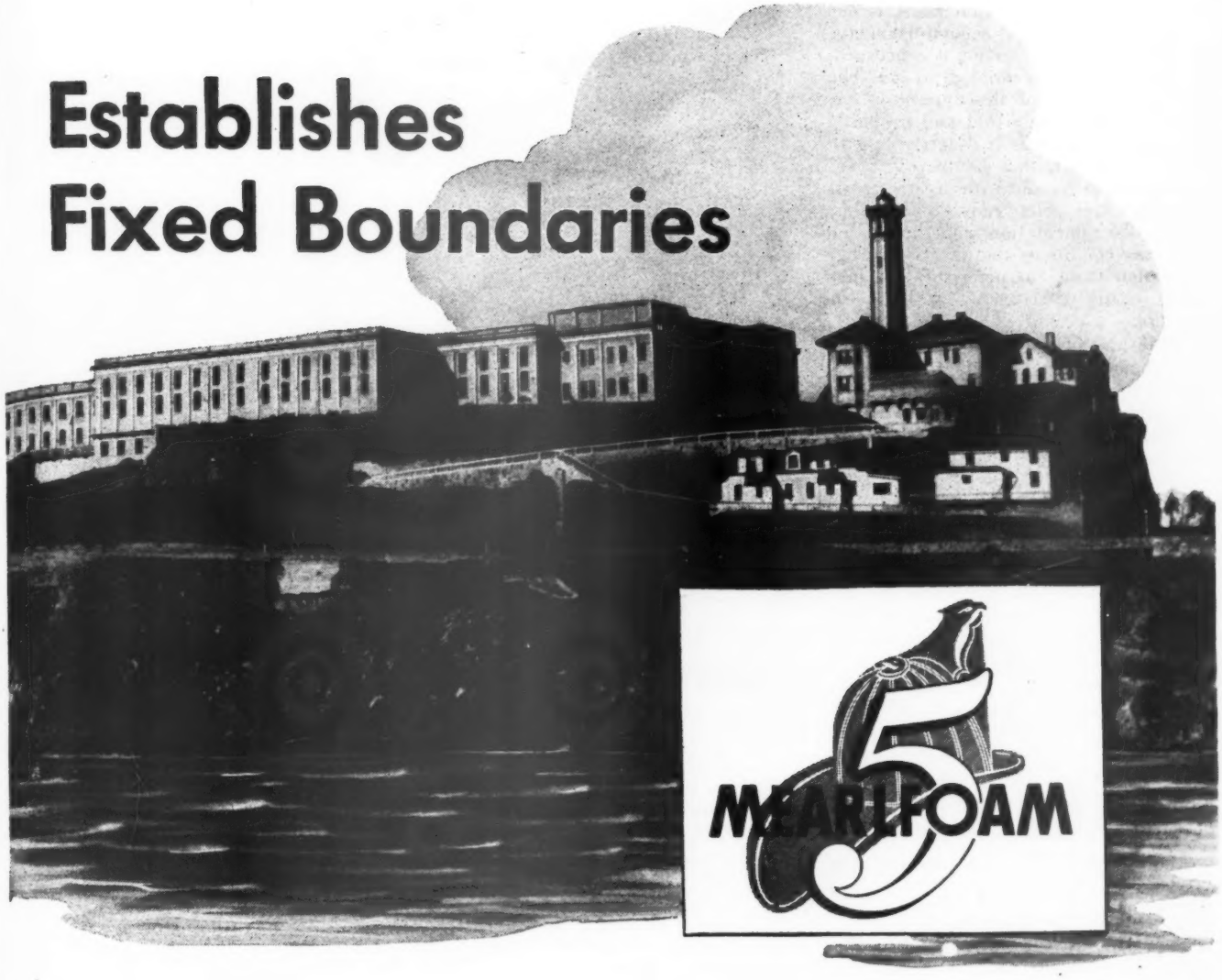


Establishes Fixed Boundaries



WASHED by the waters of San Francisco Bay, the "Rock" is law and order's way of establishing fixed boundaries for offenders. And in no less positive manner. a ring of MEARLFOAM-5, the war-born, blended multi-protein mechanical (air) foam deprives fire of its freedom and establishes its fixed boundaries, too.

When MEARLFOAM-5 puts out the infernos of blazing gasoline and oil fires they stay *put out*. Should any rupture or break occur in the dense foam blanket as the result of shipboard pitch or falling debris . . . this live, long-lasting foam remains mobile and the rupture automatically heals. Even when the blanket of MEARLFOAM-5 has aged it still retains its fire-resistance. For example:—when after aging, a hole deliberately is cut in the foam blanket (for demonstration purposes) and the gasoline or oil is reignited, the surrounding blanket confines the fire and prevents its spreading beyond the foam-circled area.

The many unique and dependable properties of MEARLFOAM-5 are the sole reasons the U. S. Navy uses it extensively for preparedness . . . and for the quick extinguishment of raging gasoline and oil fires on shipboard and at shore bases. MEARLFOAM-5 is the veteran of many successful engagements, and one day will demonstrate to all—the super effectiveness of mechanical (air) foam as the most successful, modern method for combatting gasoline and oil fires. MEARLFOAM-5, after putting fire out—*keeps it out*...totally eliminating the flash-back hazard which in the past has taken such a terrible toll of lives and property.

MEARLFOAM-5 is a good-mixer—with any type of water. It works at maximum efficiency in any climate or atmospheric condition. So that—when split-seconds count—you can rely on MEARLFOAM-5 to put fire out fast—to keep fire out *permanently!*

A one-page condensed data sheet detailing the unique properties of this war-born fire-fighting foam is now available on request. Please ask for it.

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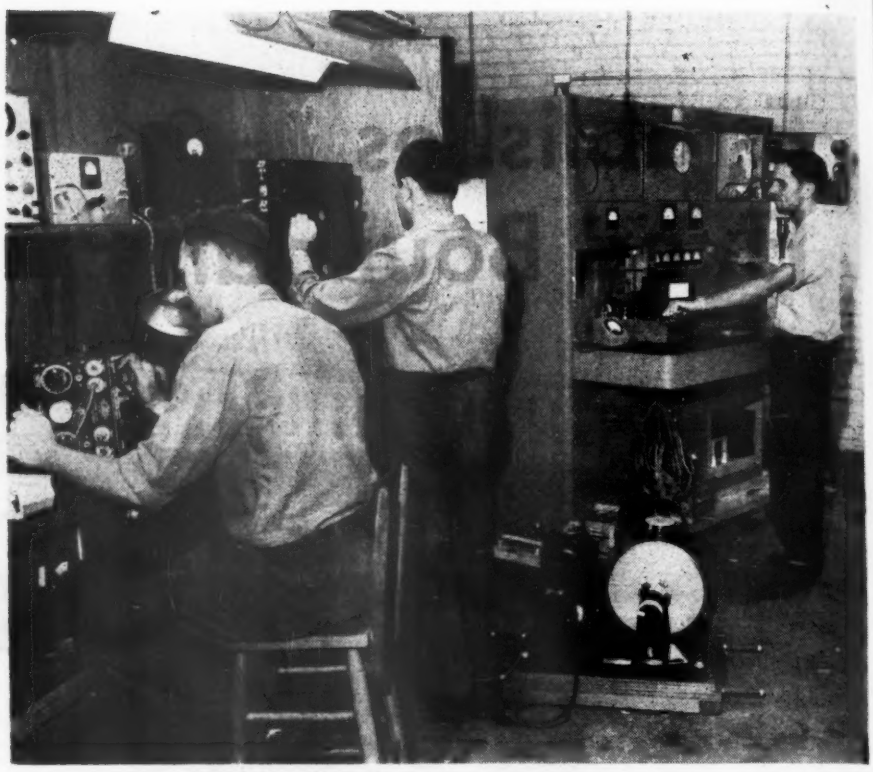
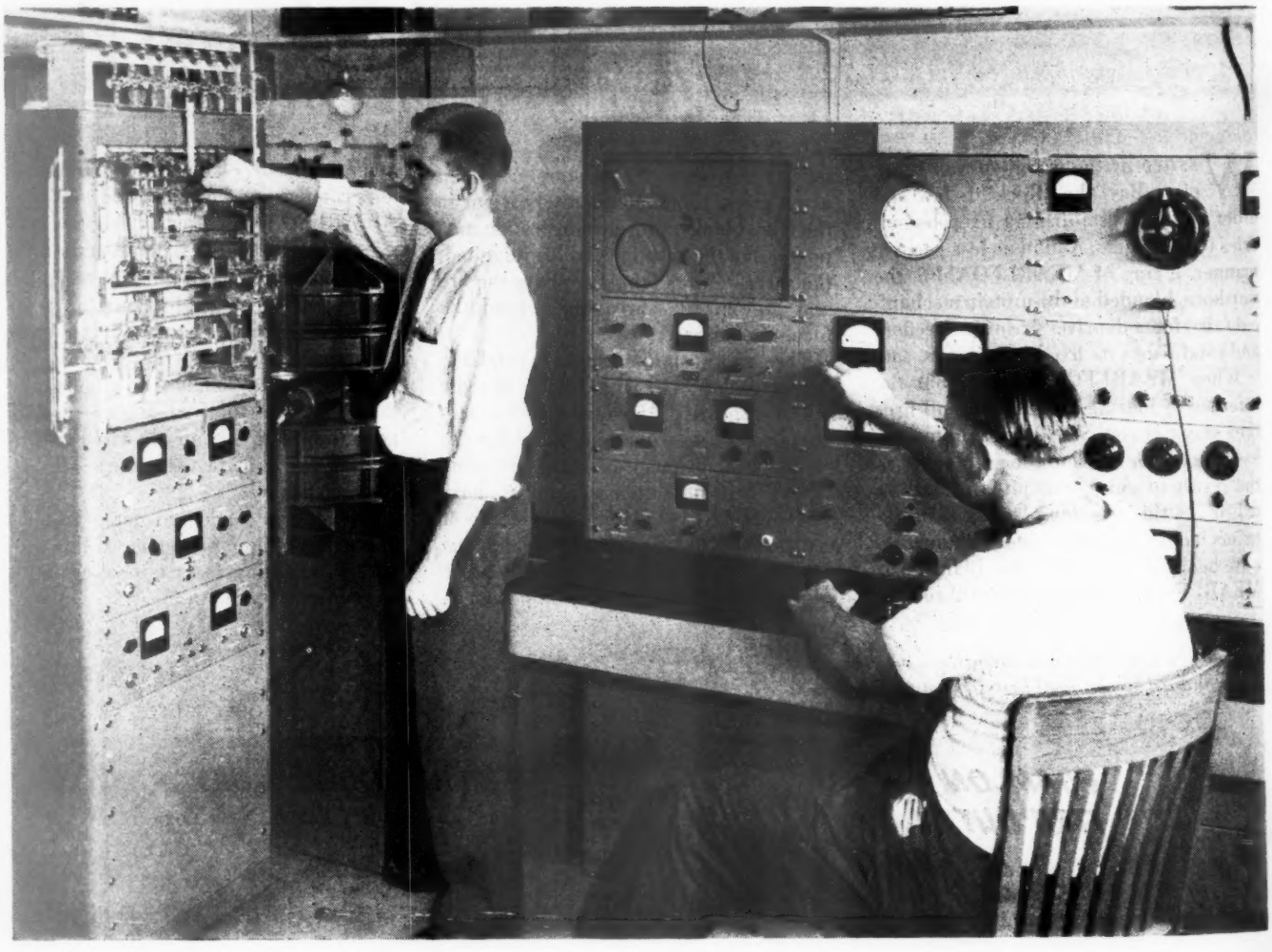
streams according to their mass, is one of the most significant accomplishments, as far as petroleum testing is concerned, of this decidedly technological era. The *modus operandi* of the apparatus has already been widely told and probably thoroughly digested. It is interesting to repeat, however, that bombardment of molecules in vacuo with a stream of electrons not only causes ionization, but also fragmentation, and that under the same conditions the degree of fragmentation is so characteristic, the machine easily distinguishes between isomers.

While the fundamental basis of mass spectrometry has been thoroughly expounded among petroleum technologists, and in principle and performance it has received generous approval, it is still sufficiently new that the widening scope of its application is a matter of deep interest. Many West Coast refineries are using the instrument for control work and there is now ample evidence that for such a purpose it has many advantages. It is remarkably accurate within the limits of its application. It is virtually automatic and for routine work can thus be operated by anyone familiar with the handling of chemical apparatus. Calculations are not too involved and are not beyond a person who has taken high school algebra. The analysis of mixtures of unknown compounds, the development of mass spectra for these, and the calibra-



Here engineers are checking a machine at the factory. Every section of the complicated assembly is tested and calibrated in order to assure highest degree of accuracy.

This is the modern machine at work in a modern refinery where it is being used to control the intricate processes employed in manufacture of high octane aviation fuels.



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tion of the machine itself, are matters for a qualified physicist and, of course, are beyond the capacity of an inexperienced operator.

An attractive feature of the machine is its sensitivity. It distinguishes between compounds that are very similar in character and sometimes as in the case of isomers, are actually of the same atomic weight. It can, indeed, identify any light hydrocarbon so long as there is a pattern of the pure compound available with which to compare it. Up to the moment it has been used with distinct satisfaction, as a routine tester on a wide range of hydrocarbon mixtures of which the following are typical examples:

1. **Dry gas**
2. **Wet gas**
3. **n-Butane and iso-butane**
4. **C_1 through C_4 paraffin and olefin**
5. **C_3 through C_5 paraffin and olefin**
6. **C_4 paraffins and olefins**
7. **C_4 paraffins, olefins and diolefin**
8. **C_5 paraffins, olefins, diolefins and cylics**
9. **C_5 through C_6 paraffins, cylics and aromatics**
10. **C_7 paraffins, C_8 paraffins**
11. **Determination of benzene, toluene and xylenes in gasoline**
12. **Determination of small amounts of diethylbenzene in ethylbenzene**

In this connection, it should be pointed out that through the API and other associations and agencies, spectra of a gradually increasing list of pure compounds are becoming available for standardization and calibration. Already the API has had prepared in excess of 50 hydrocarbon compounds of high purity. These may be acquired by mass spectrometer operators or, in fact, the operators of any physical machine in which they might be used to promote technological progress in the industry.

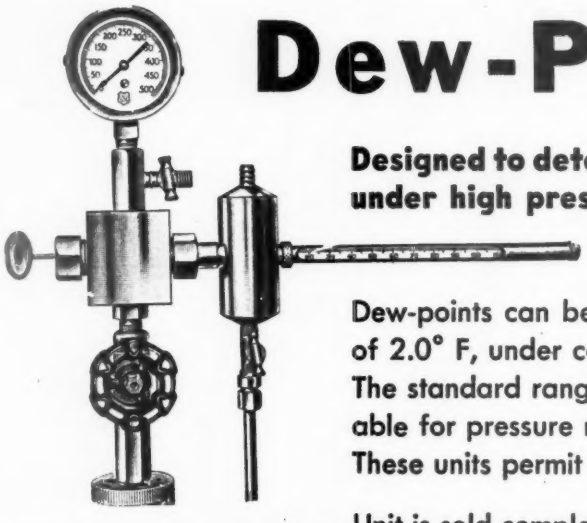
Consolidated Engineering Corporation physicists are constantly experimenting with new compounds and new mixtures to extend the application of the machine, to develop improvements in technique, and to search for possible improvements in design. This provides an additional source of analytical data and general information that adds substantially to the sum total. There seems to be a healthy desire among operators to pool experience and exchange ideas, and it is not at all improbable that in the near future the related industry associations may institute "mass spectrometer divisions."

With all its desirable qualities—accuracy, sensitivity, simplicity of operations, etc.—the mass spectrometer also incorporates the virtue of speed. One laboratory started a machine on control work just 13 months ago, and has had it in operation nearly 24 hours a day. During that time it has analysed approximately 11,000 samples and has long since paid off its initial cost in the saving of man hours. An actual routine test run on this machine takes about one-eighth of the time required by the distillation method for the same test, and it is estimated that the difference in cost amounts to about $6 per sample.

The question of elapsed time per sample is one that is greatly influenced by the character of the test and the experience of the operator. Even in complex mixtures, for example, it is sometimes only necessary for control purposes to determine the content of a single constituent. After the normal test routine has been performed completely on several samples, the operator may become sufficiently familiar with the spectra to be able almost to gauge the proportion of the significant element or compound by a glance at the photographic record. With still further experience this facility may be extended to the determination of several components in a mixture.

Over a wide range of conditions and for a formidable array of mixtures, thus, the mass spectrometer has proved itself to be a valuable control instrument. It has so far withstood the penetrating scrutiny of one of the world's greatest skeptics—the petroleum chemist—that he is about to elevate it to a higher scientific plane. It has so proved, not only its reliability, but also its potential capability, that it has been adopted as a petroleum research tool.

In future, besides helping to stabilize and control the manufacturing processes of the petroleum industry, it will be engaged in the delicate business of breaking up hydrocarbon molecules and finding out what new magic can be performed with the pieces. ★★★



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SIMPLIFICATION OF GAS FLOW CALCULATION BY MEANS OF A NEW SPECIAL SLIDE RULE

By **B. F. GRIZZLE,** *Gas Division, Office of War Utilities*

EXCLUSIVE

INTRODUCTION. The transmission of natural gas by pipe line has progressed a long way in the past 72 years since gas was first transmitted through wooden pipes for short distances at low pressures. Today thousands of miles of high pressure steel pipe lines are in use conveying millions of cubic feet of gas every day from sources of supply, which, in many cases are over a thousand miles from points of consumption. These lines run up to 26-in. in diameter with operating pressures as high as 1300 lb. per sq. in. in some instances.

The economic feasibility of long transmission lines of high capacity in most cases depends a great deal on careful design and estimates of performance which can be depended upon. It is highly essential, therefore, in connection with the design of natural gas transmission projects, that the estimated performance of the lines checks very closely with the actual performance. To accomplish this it is necessary that the method of flow calculation and formulae used be the best available.

Over a period of years quite a number of individuals have contributed to the mathematical methods of gas flow calculations and many have determined empirical formulae that, for their purposes, and within the range of sizes, lengths, and pressures with which they were directly concerned, were satisfactory. Many of these formulae, however, which were formerly considered accurate, have been applied outside of their intended range of applicability and, consequently, their use under these conditions has introduced errors too large to be ignored.

It is the purpose of this article to discuss empirical gas flow formulae and to select one that will give accurate results throughout a wide range of applicability. In selecting a satisfactory working formula for gas flow, actual metered flow on existing transmission lines has been analyzed and compared with the results of various formulae. As a result of this study, it appears that a formula recently developed by the Panhandle Eastern Pipe Line Company offers an accurate and practical method of calculation of gas flows for transmission lines. It is not suitable for distribution systems at low Reynolds numbers. The development of this formula is discussed in this article as well as the mechanics of its use when applied to single, parallel, and complex pipe line systems.

In an effort to simplify the calculation of pipe line flows, the author has developed a slide rule based upon the Panhandle formula, the use of which makes it possible to solve practically all types of problems connected with the flow of natural gas in pipe lines by means of one or two very simple operations. This slide rule and how it may be used to solve the various types of pipe line computations is described herein.

This article is divided into the following sections:

1. ***A discussion of the mathematical development of gas flow formulae with reference to the work of other authorities on the subject.***
2. ***Development of the Panhandle gas flow formula.***
3. ***A discussion of the various operating tests on existing pipe lines and of the calculated results obtained from various pipe line flow formulae in comparison with actual test results.***
4. ***A description of a special slide rule based upon the Panhandle formula.***
5. ***Appendices and references.***

1. Mathematical development of gas flow formulae

An empirical formula is based on, or guided by experience or experiment rather than by reasoning or theory. Therefore, the conditions under which an empirical formula is to be used should be consistent with the experiments upon which the formula was based. The extrapolation and extension of an empirical formula beyond the calculated range cannot be relied upon.

The Weymouth formula has been extrapolated far beyond the field discussed by Weymouth. His original article states that the coefficient of friction was determined by tests on the flow of air through pipes. These tests were published by Elmo G. Harris. No statement was made as to what methods were used in measuring the flow. These tests, plotted in Fig. 2 of Weymouth's article, are on pipe from approximately 0.8 in. to 11.8 in. inside diameter.

The Miller formula, published eight years ago, was the result of actual tests and agrees very closely with recent experience when an efficiency of 92 per cent is used in his formula.

Biddison's formula, presented four years ago, also agrees very closely with actual experience. The efficiency tests made by the Panhandle Eastern Pipe Line Company are in close agreement with the results obtained from the Miller and Biddison formulas. Miller and Biddison agree with each other within a fraction of a per cent at all pressures, diameters, and lengths as shown in Fig. 1.

The "Coefficient of Friction" is the all important factor in any formula for estimating the flow in pipes, and it is the value of this factor on which authorities differ.

The general equation[1] for the flow of natural gas is

$$Qh = 1.6156 \frac{To}{Po}\left[\frac{(P_1^2 - P_2^2)\,d^5}{GTLf}\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots \quad (1)$$

The symbols used in this article are defined as follows:

Qh = cubic feet gas per hour at pressure and temperature bases Po and To (14.735 lb. and 519.6°F. absolute)

Q = cubic feet gas per hour at pressure and temperature bases Po and To (14.735 lb. and 519.6°F. absolute)

q = cubic feet free gas per second $= \frac{Q}{86{,}400}$

A = area of inside of pipe in square feet $= \frac{.7854d^2}{144}$

d = inside diameter of pipe in inches $= \frac{D}{12}$

D = inside diameter of pipe in feet $= 12d$

L = length of pipe, miles

To = temperature basis defining a cubic foot of gas degrees F. absolute, (519.6°F.)

Po = pressure basis defining a cubic feet of gas, pounds per square inch absolute (14.735)

Ta = actual temperature, degrees F. absolute

P_a = actual pressure, pounds per square inch absolute

P_1 = inlet pressure, pounds per square inch absolute

P_2 = outlet pressure, pounds per square inch absolute

T = actual temperature of flowing gas, degree F. absolute

G = specific gravity (.60) of gas (air = 1.0)

U = velocity feet per second.

E = assumed efficiency of pipe line 0.92 or 92 per cent

f = coefficient of friction; $\sqrt{\frac{1}{f}}$ = friction factor

S = density, pounds per cubic foot. Air = (.08071 lb. per cu. ft. at 760 mm. mercury and 32°F. abs.)

Z = viscosity in pounds per second foot = .000007 (assumed average value from Fig. 23 Monograph 6)[1]

1.6156 is a constant for equation (1).

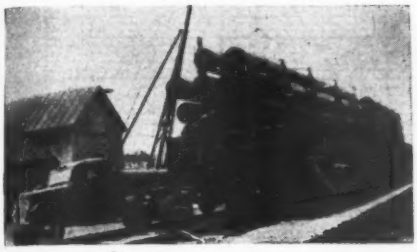
The general equation is expressed in several modified forms,

"Fluid and Flexible"... *he says*

THAT, ZHUKOV, is also the battle cry of oil country strategists using Arc Welding to win business victories. In pipe line construction, for example:

HOW THE FUEL FOR WAR GOT THERE *ON TIME*

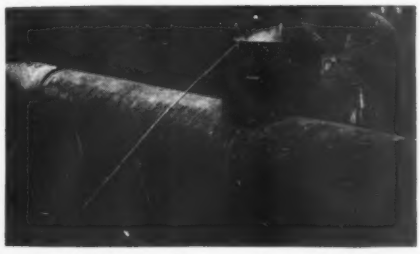
During the past three years, 18,000 miles of pipe line (such as Big Inch) have been built in record schedules by this fluid and flexible method:



1 Contractor loads pipe onto truck, then strings it along right-of-way.

2 Line-up crew sets pipe sections on dollies and clamps ends of pipe.

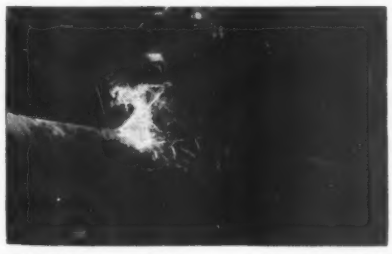
3 Tack welders join clamped ends at several points in circumference.



4 Firing line welders make welds downhand with pipe turning.*

5 "Hot dope" gang impregnates the pipe where soil is corrosive.

6 Tie-in gang heaves a strong, rigid 150′ section over to ditch.



7 Bell-hole welders complete the tie-in of sections.*

8 Down goes the line—arc welded to stay.

9 Complete procedures in Bul. 418. Ask for it on your letterhead.

**On many lines, this step is eliminated; all welding done at Step No. 3. This is the "stove-pipe" method.*

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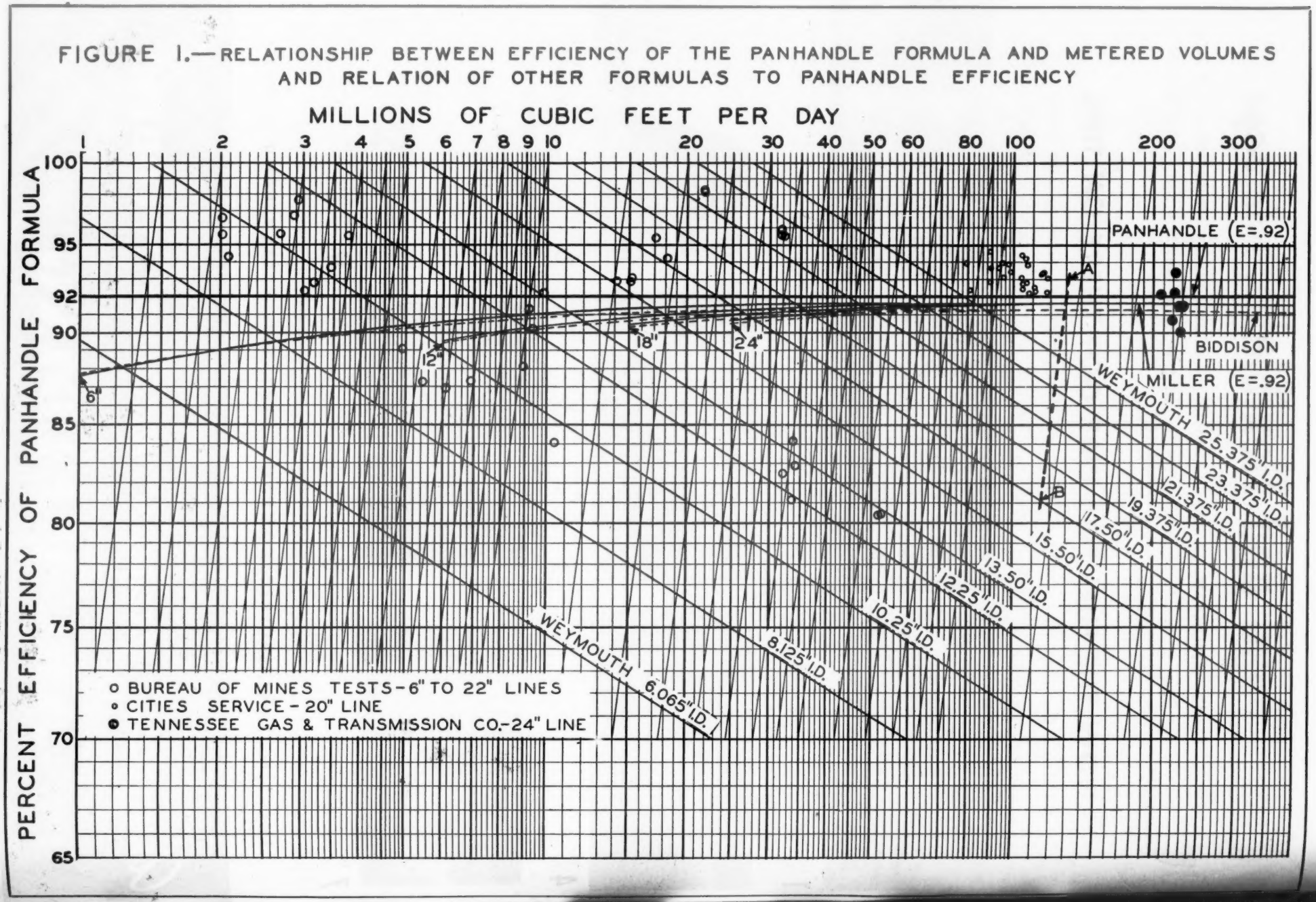
ARC WELDING

FIGURE 1.—RELATIONSHIP BETWEEN EFFICIENCY OF THE PANHANDLE FORMULA AND METERED VOLUMES AND RELATION OF OTHER FORMULAS TO PANHANDLE EFFICIENCY



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depending upon the value of the coefficient of friction, and the temperature and pressure bases.

This general form was used by Weymouth[2] in his paper; it is numbered equation (10). In Benjamin Miller's[3] paper, it is equation (2). Also in P. McDonald Biddison's[4] paper, it is equation (2).

Weymouth[2] in his formula evaluates the coefficient of friction as a function of the diameter, as follows:

$$f = \frac{.008}{d^{1/3}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Substituting this value in the general formula we have

$$Q = 433.488 \frac{To}{Po}\left[\frac{(P_1^2 - P_2^2)\,d^{16/3}}{GTL}\right]^{1/2} \quad \ldots\ldots\ldots \quad (3)$$

which is the Weymouth formula.

Benjamin Miller[3] showed how the friction factor could be computed from the specific gravity, pressures, diameter, length, temperature and viscosity.

$$\sqrt{\frac{1}{f}} = 2 \log \frac{G(P_1^2 - P_2^2)\,d^3}{LTZ^2} - 3.66 \quad \ldots\ldots\ldots \quad (4)$$

Substituting this value in the general equation we have

$$Q = 3.2312 \frac{To}{Po}\left[\frac{(P_1^2 - P_2^2)\,d^5}{GTL}\right]^{1/2}$$

$$\left[\log \frac{G(P_1^2 - P_2^2)\,d^3}{LTZ^2} - 3.66\right] \quad \ldots\ldots\ldots\ldots \quad (5)$$

which is the Miller formula.

Miller suggests an E Factor of 92 per cent, which we may call the efficiency factor, sometimes referred to as an experience factor.

P. McDonald Biddison[4] is in close agreement with Benjamin Miller taking into account the same factors with different "constants," where Z = .000007.

$$\sqrt{\frac{1}{f}} = 1.81 \left[\text{Log} \frac{6.1565 \times d^3 \times G \times (P_1^2 - P_2^2) \times 10^6}{T \times L}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Substituting in the general formula we have

$$Q = 2.9242 \frac{To}{Po}\left[\frac{(P_1^2 - P_2^2)\,d^5}{GTL}\right]^{1/2}$$

$$\text{Log}\left[\frac{6.1565\ (P_1^2 - P_2^2)\,d^3 G \times 10^6}{TL}\right] \quad \ldots\ldots\ldots \quad (7)$$

Biddison has included the efficiency factor in the friction factor.

The methods used by the above authorities in determining the friction factor are discussed in the papers cited in the references.

Biddison and McKay[5] suggest a close approximation of equation (6) over a considerable range of Reynolds numbers in the form of a power equation which is more easily handled. This friction factor is expressed as:

$$\sqrt{\frac{1}{f}} = 5.87372\ R^{0.077174} \quad \ldots\ldots\ldots\ldots \quad (8)$$

Substituting in the general equation this becomes

$$Q = \left(\frac{P_1^2 - P_2^2}{L}\right)^{.5418139} 607.984 \left(\frac{d^{2.625442}}{G^{.458186}}\right) \quad \ldots\ldots \quad (9)$$

Drew and Genereaux[6], for commercial pipe proposed the friction factor

$$\sqrt{\frac{1}{f}} = 3.2 \text{ Log } (R\sqrt{f}) + 1.2. \quad \ldots\ldots\ldots \quad (10)$$

Nikuradse's[7] results for smooth pipe has been expressed as

$$f = 0.0008 + 0.0552\ (R)^{0.237} \quad \ldots\ldots\ldots\ldots \quad (11)$$

or

$$\sqrt{\frac{1}{f}} = 4 \text{ Log } (R\ \sqrt{f}) - 0.4 \quad \ldots\ldots\ldots \quad (12)$$

Values of the above friction factors are shown in Appendix I and plotted in Fig. 2.

An engineer in using a formula should be sure that it is applicable to the conditions with which he is dealing.

The author has been unable to find in the literature on this subject any definite statement as to the limitations of the Weymouth formula, although it is well known among engineers that there are limitations.

Hancock[8] refers to the "intended scope" of the Weymouth formula but does not indicate what he considers it to be.

Diehl[9] says that the Weymouth formula probably represents the average maximum capacities of new lines built under 1927 conditions, but points out that "tests have indicated that the capacities of some lines are 10 per cent greater," than those derived from the formula.

Wills[10], after noting the general acceptance of the Weymouth formula states that "the friction factor used by Weymouth is too low when the pipe diameter exceeds 22 in. and especially when gas velocities are high."

Johnson and Berwald[1] found in their flow tests of commercial pipe lines that for the large diameter lines the metered rates of delivery agreed more closely with the calculated rates from Weymouth's formula than with those calculated from any other formulae published at that time, and they state that "in the majority of tests made under favorable test conditions, the metered volume was larger than the volume found by the Weymouth's formula;" also that "the application of Weymouth's formula to pipe lines smaller than 6 in. in diameter may give considerable error."

Benjamin Miller[3] pointed out that under very light load conditions Weymouth's formula would give flow rates that were too high, but under peak load conditions it would give flow rates that were too low.

This rather brief discussion of the many factors which may make the actual pipe line capacity different than that predicted by any formula may serve to explain the success with which the Weymouth formula has been used.

2. The Panhandle gas flow formula

The "Panhandle" formula recently developed by the engineers of the Panhandle Eastern Pipe Line Company combines a friction factor with the general formula and uses a similar arrangement of factors as the Weymouth formula with different exponents and constants, and introduces the factor E into the formula.

$$Q = 883\ E \left(\frac{P_1^2 - P_2^2}{L}\right)^{.5394} d^{2.6182} \quad \ldots\ldots\ldots \quad (13)$$

The average efficiency of approximately 92 per cent used in the Panhandle formula was obtained from actual experience wherein the metered flows were corrected to standard conditions, including correction for deviation from Boyles Law.

The Panhandle formula was derived as follows: The expression for the Reynolds[11] number (R) is

$$R = \frac{DUS}{Z} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Transferring these units in common terms of gas flow

$$D = \frac{d}{12};\ U = \frac{q}{A} \times \frac{Po}{Pa} \times \frac{Ta}{To}$$

$$S = .08071 \times G \times \frac{491.6}{Ta} \times \frac{Pa}{760 \times .01934}$$

Z assumed as .000007

$$\text{By simplification } R = 1.934 \frac{QG}{d} \quad \ldots\ldots\ldots \quad (15)$$

It was found by actual metered experience on the Panhandle Eastern Pipe Line that for Reynolds' numbers from 5,000,000 to 11,000,000

$$\frac{1}{f} = 52.0\left(\frac{QG}{d}\right)^{.1461} \quad \ldots\ldots\ldots\ldots \quad (16)$$

$$\text{or } \sqrt{\frac{1}{f}} = \left[52.0\left(\frac{QG}{d}\right)^{.1461}\right]^{1/2} \quad \ldots\ldots\ldots \quad (17)$$

Substituting equation (17) in the general equation:

$$Q = 38.7744 \frac{To}{Po}\left[\frac{P_1^2 - P_2^2)\ d^5}{GTL}\right]^{1/2}$$

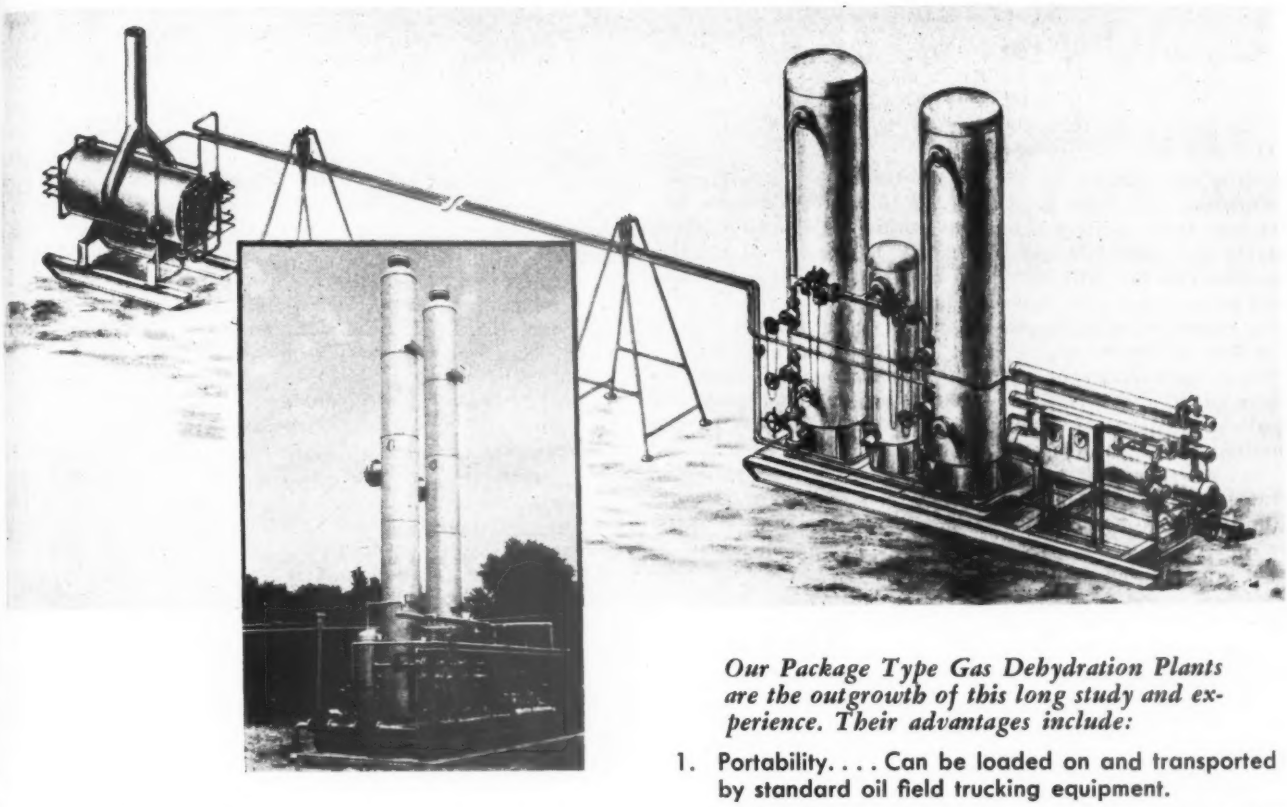
$$\left[52.0\left(\frac{QG}{d}\right)^{.1461}\right]^{1/2} \quad \ldots\ldots\ldots\ldots \quad (18)$$

$$Q^2 = 52\left[38.7744 \frac{To}{Po}\right]^2$$

$$\left[\frac{(P_1^2 - P_2^2)\ d^5 \times G^{.1461} \times Q^{.1461}}{GTL\ (d)^{.1461}}\right] \quad \ldots\ldots\ldots \quad (19)$$

Announcing

PACKAGE TYPE *Natural Gas* DEHYDRATION PLANTS



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3. Dehydration to pipe line specifications, 5 to 20 m.m.c.f. of gas per day, 400 to 1200 pounds pressure.
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$$Q^{1.8539} = 52\left[38.7744\,\frac{To}{Po}\right]^{2}\left[\frac{(P_1^2-P_2^2)\,d^{4.8539}}{G^{.8539}TL}\right] \quad (20)$$

$$Q = 52^{.5394}\left[38.7744\,\frac{To}{Po}\right]^{1.07881}\left[\frac{(P_1^2-P_2^2)}{G^{.8539}TL}\right]^{.5394} d^{2.6182} \quad (21)$$

$$Q = 435.87\left(\frac{To}{Po}\right)^{1.07881}\left[\frac{(P_1^2-P_2^2)}{G^{.8539}TL}\right]^{.5394} d^{2.6182} \quad (22)$$

Substituting for $To = 60 + 459.6 = 519.6$
$Po = 14.735$
$T = 60 + 459.6 = 519.6$
$G = .600$

$$Q = 883\ (P_1^2-P_2^2)^{.5394}\, d^{2.6182} \quad (23)$$

which is the equation for flow of gas through *smooth* pipes.

Equation (23) may be considered as applicable for a perfect line under perfect conditions within a reasonable range outside R = 5,000,000 and 14,000,000. The actual capacity of a commercial line will always be less than the capacity calculated by equation (23). Commercial gas lines under good operating conditions may be rated in terms of the perfect line, or pipe line efficiency.

Some approximate or probable efficiency must be used in design calculations. This should be based upon experience and results of actual tests. Where it is not known that any special conditions exist, an efficiency of 92 per cent can be expected for the new construction, an efficiency of 95 per cent may be obtained under very good conditions, and only unusually unfavorable conditions will cause the efficiency to drop below 85 per cent.

Let pipe line flow efficiency = E

$$Q = 883\ E\left(\frac{P_1^2-P_2^2}{L}\right)^{.5394} d^{2.6182} \quad (24)$$

when E = .92, equation (24) becomes:

$$Q = 812.36\ d^{2.6182}\left(\frac{P_1^2-P_2^2}{L^{.5394}}\right)^{.5394} \quad (25)$$

For pressure conditions, equation (25) may be rewritten

$$P_1^2-P_2^2 = \frac{Q^{1.8539}L}{247{,}960\ d^{4.8539}} \quad (26)$$

3. Operating tests on pipe lines

A perfect line is assumed to be straight, round, level, and the inside walls clean and smooth. Perfect operating conditions are assumed to have a pressure drop which is due only to pipe friction. Another assumption is that the flow is steady, that is, the same weight of gas passes each point in a pipe line during an interval of time, and the temperature is constant.

These conditions seldom occur in actual operation, and since variations are often difficult to consider in a formula, corrections must be made.

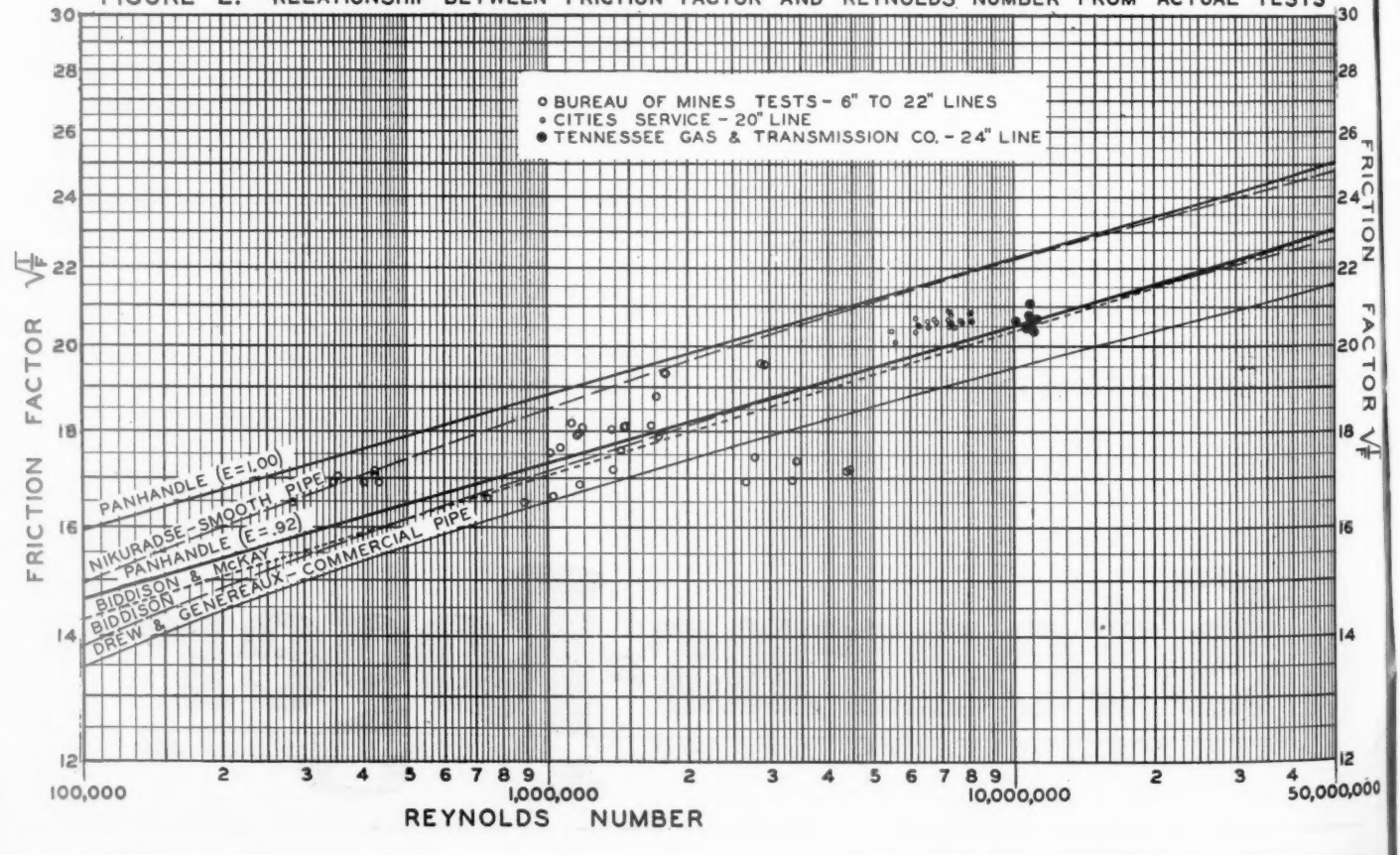
From these assumptions an average efficiency factor can be applied for the internal roughness for commercial pipe. However, variations in the value of E can be expected in the number of bends per mile. Valves, fittings, drips, siphons, river crossings, etc., tend to reduce the flow capacities and affect the value of E in each particular line. Most pipe lines are not level and where considerable difference in elevations occur, in order to compare with horizontal lines, it is necessary to make corrections when the pressure drop is small.

Tests[12] from operating data on each section of the new 24-in. Tennessee Gas and Transmission Company's line from Corpus Christi, Texas, to West Virginia are tabulated in Table 1, and plotted in Figs. 1 and 2. These show an efficiency from 90.0 to 93.4 per cent. These tests were made within six months after completion of the line. The average efficiency for the entire 1,176.5 miles of 24-in. line was 91.75 per cent.

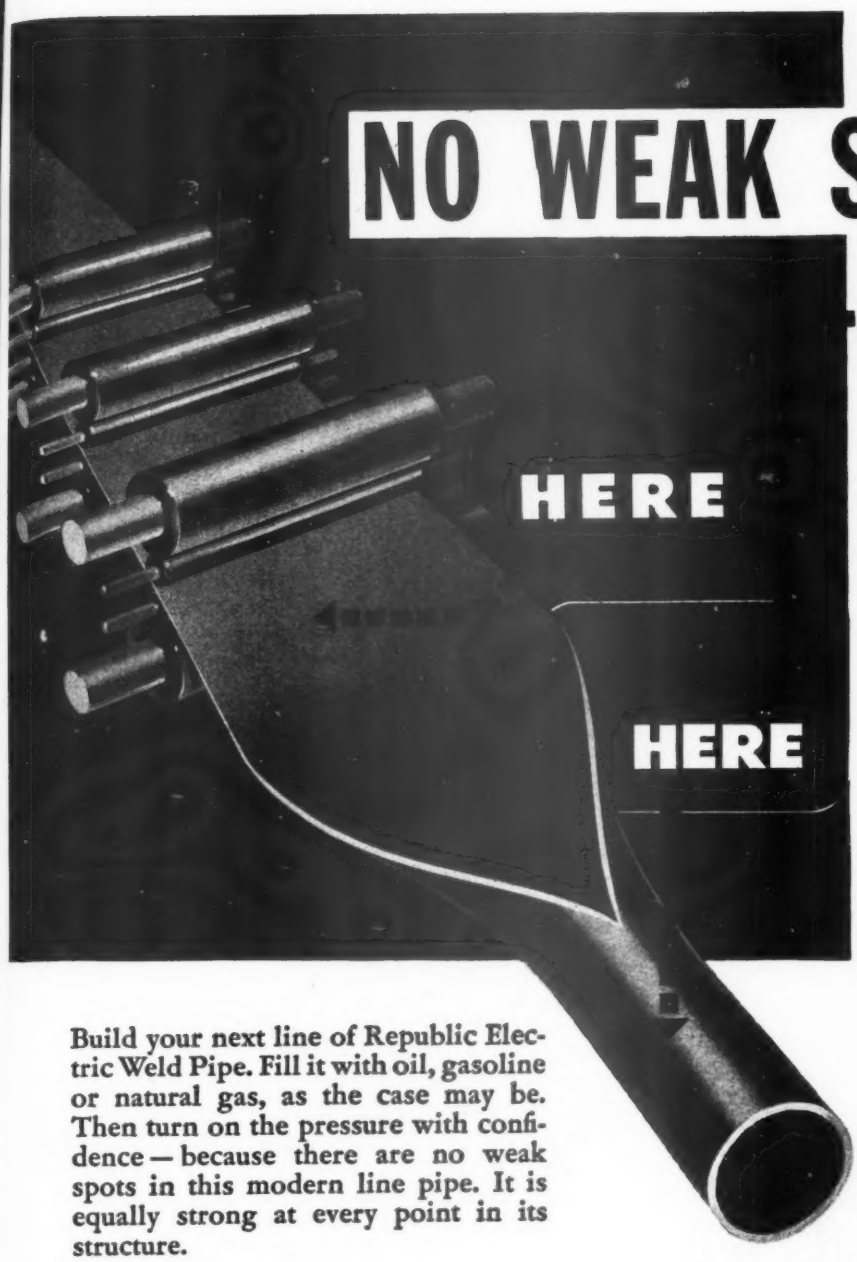
A large number of tests[13] on the two sections of a line which carries gas from the Texas Panhandle to Wichita showed efficiencies varying from 92.1 to 94.7 per cent. These are tabulated in Table 2, and plotted in Figs. 1 and 2. This line was constructed in 1927, and the tests were made in 1935.

From these recent tests plotted in Tables 1, 2, and 3, it is sufficiently conservative to take 92 per cent as the probable efficiency for design calculations. Calculations made by the Panhandle formula using a 92 per cent efficiency factor; the Miller formula using 92 per cent; and the Biddison formula, all agree within 1 per cent for any 6-in. to 24-in. diameters.

FIGURE 2.—RELATIONSHIP BETWEEN FRICTION FACTOR AND REYNOLDS' NUMBER FROM ACTUAL TESTS



NO WEAK SPOTS



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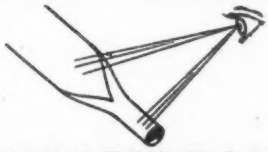

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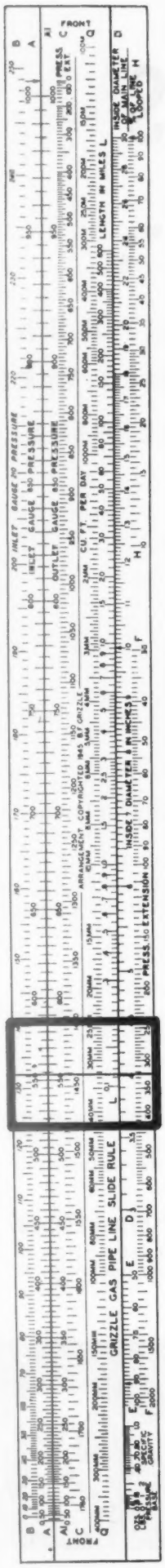


FIGURE 3. (REDUCED FROM 12 IN.)

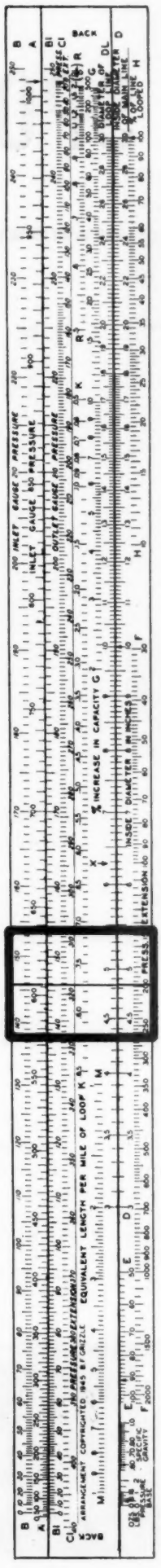


FIGURE 4. (SLIDE REVERSED.)

length, and pressure for capacities above 50 million cu. ft. per day as shown by Fig. 1.

Thirty-five of the tests reported by Johnson and Berwald[1] have been calculated for efficiencies. They are shown in Table 3 and plotted in Figs. 1 and 2. Of the above 35 tests, which were made on supposedly clean lines under steady flow conditions with a pressure drop greater than 10 lb. per sq. in., 7 showed efficiencies of 80 to 85 per cent; 5 were in group 85 to 90 per cent efficient; 11 were between 90 and 95 per cent efficient; 10 were between 95 and 98 per cent, and 2 were slightly above 98 per cent. Other tests by Johnson and Berwald were rejected. (See Table 3.)

The discussion of the foregoing tests has been largely confined to those on large diameter lines. The smallest size diameter commercial lines on which we have flow tests are those reported in Bureau of Mines Monograph 6, which are on 6-in. lines. These are included in Table 3.

The average efficiency of the 35 tests made by the Bureau of Mines on lines from 6 in. to 22 in. in diameter was 91.16 per cent. These tests included the leakage. The age of these lines at the time the tests were made was from 2 months to 30 years.

The efficiency factor of .92 in the Panhandle formula is for an average normal, clean, commercial, welded steel pipe line. In every gas pipe line there are numerous fixed and variable factors affecting the flow of gas that do not correspond with the efficiency factor of .92.

These factors are taken care of in the Panhandle formula by the Factor E and must be determined by tests.

The fixed factors may be: number of bends, valves, fittings, swedges, drips, joints per mile, type of joints, and difference in elevation of inlet and outlet. Some recent tests on new lines over 12 in. in diameter indicate efficiencies from 85 to 88 per cent in very hilly and rugged country compared to almost 95 per cent in some instances in exceptionally flat country.

Tests on lines 7 and 10 in Table 3 show efficiencies from 80.45 to 82.91 per cent by the Panhandle formula. Johnson and Berwald[1] show these lines have a large number of drips, valves and bends and traverse mountainous country. In the 32-mile section of line 7, included in the test, there were many sharp vertical bends, fourteen 90-deg. turns, thirty-seven 45-deg. turns and many other turns of lesser degree. In addition to the numerous bends and turns this line contained 1 complex drip, 41 simple drips, and 13 twelve-inch valves connected into the 15-in. line by swaged nipples. In the 50 miles tested of line 10, there were 106 simple drips, 1 complex drip, 15 valves and numerous bends and turns.

The variable factors may be caused by deposits or condensates in the line or the changing condition of the interior pipe surface or wall roughness.

An example of efficiencies caused by the variable factors is shown by Trelease[14] on the Amarillo-Denver line. An 86-mile section of the Amarillo-Denver 22-in. line showed an efficiency of 85.9 per cent prior to running a scraper. After a scraper was run through the first 42½ miles, the efficiency was 101.1 per cent. After the scraper had been run through the entire 86 miles the overall efficiency was 106.7 per cent. These efficiencies were expressed on the basis of the Weymouth formula, 100 per cent being the calculated value after correction for elevation. Before running the scraper, one section of the 86 miles showed an efficiency of 66.8 per cent, and another section 74.9 per cent.

Therefore, the factor E is introduced in the Panhandle formula to take care of all these factors that deviate from the normal conditions and the actual value of E must be determined by tests.

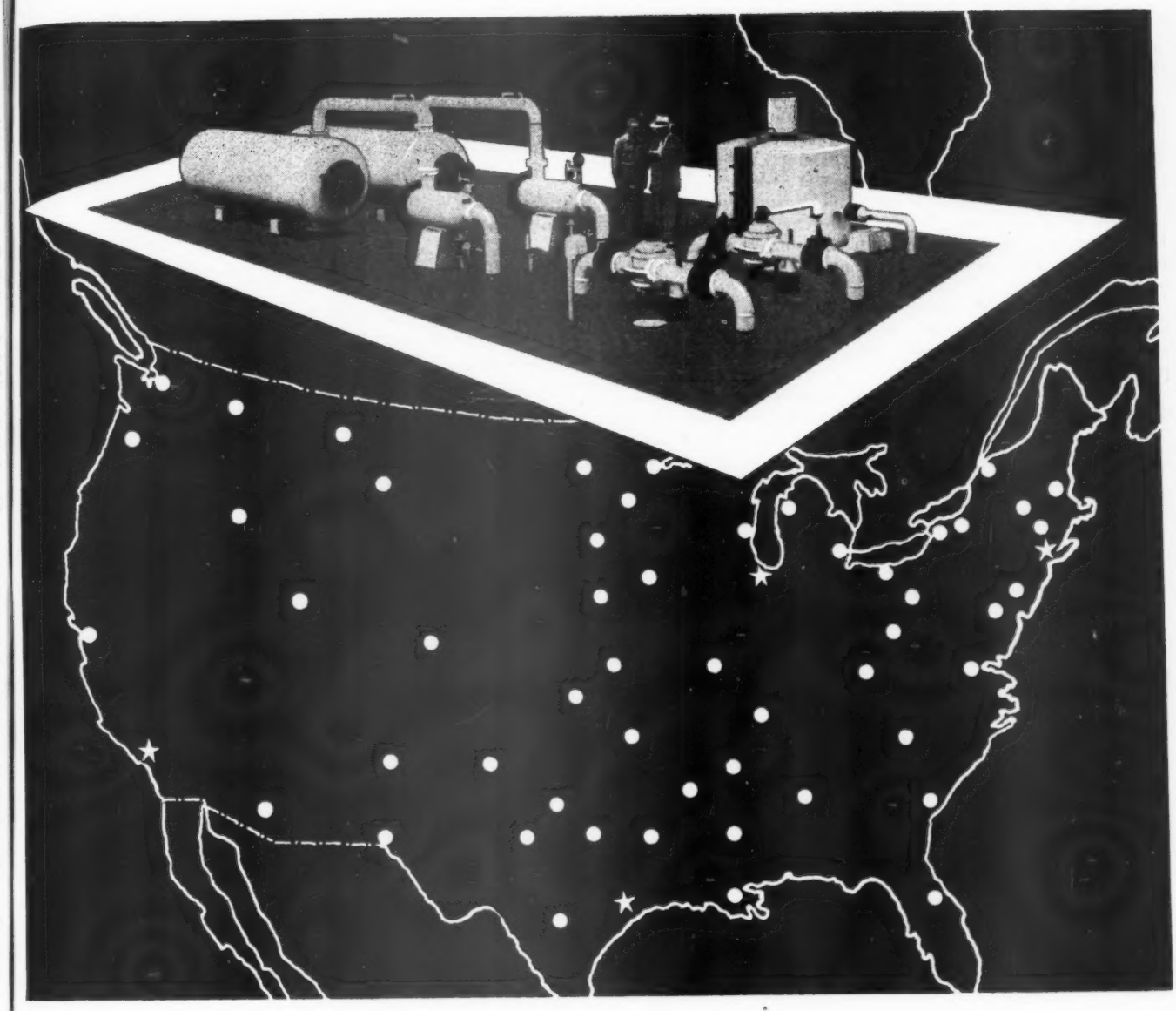
Although the friction factor 17 used in the Panhandle formula was limited by actual tests for Reynold's number from 5,000,000 to 11,000,000 on the Panhandle Eastern 24-in. line, it also checks very closely with the tests on the 6-in. diameter lines as reported in Bureau of Mines Monograph 6.

The five tests on two 6-in. lines in Table 3 (Lines 27B and 29) agree closely with the Panhandle formula when the Reynolds number is as low as 451,000. These two 6-in. lines were 6 months old and 2 years old. These tests show the Panhandle formula agrees more closely than the Weymouth formula where Reynolds numbers are as low as 451,000 and it agrees very closely to actual flows with Reynolds numbers around 1,000,000. Line 29 is of special interest due to the high specific gravity.

In the absence of available tests on lines under 6 in. in diameter, no prediction for extrapolation to 2-in., 3-in., and 4-in. diameter lines is made using the Panhandle formula; however, in view of the above tests it is reasonable to assume that the formula would hold within a few per cent for new, clean 3-in. and 4-in. lines.

4. Special slide rule based on the Panhandle formula

● **Description.** Due to developments of the past few years in the design, construction and operation of pipe lines for the transmission of natural gas, the engineering problems have become quite complicated. Long hand computations take much time and are tedious: nomographs are not too accurate and rather inconvenient. With this thought in mind the author has designed and has made a special slide rule based on the "Panhandle Formula." It saves a great deal of time, is accurate and reliable, and can be applied to problems of complicated systems.



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The special slide rule designed for these calculations is illustrated in Figs. 3 and 4 and can be used to compute practically all types of pipe line flow problems.

Most natural gas pipe line systems do not consist of a single length of one-diameter pipe but rather of sections of different diameter pipes or of sections paralleled or looped with other lines. As the demand for gas increases it is common practice to parallel sections of the system with pipe of the same or different diameter. Extensions of old systems often are constructed of a diameter of pipe different from the original. Ever changing conditions of both the source of supply and the demand have resulted in complex systems, the design of which requires special handling of the flow formulae. The following examples illustrate the application of the Panhandle flow formula (with E = .92) to special problems on complex systems, and gives examples solved mathematically and computed by special slide rule.

Equation (25), the formula for a single line at standard conditions (E = .92), is the form used in the following derivations and examples:

$$Q = 812.36 \frac{d^{2.6182} (P_1^2 - P_2^2)^{.5394}}{L^{.5394}} \quad . . . . . (25)$$

Equation (25) may be rewritten for pressure conditions

$$P_1^2 - P_2^2 = \frac{Q^{1.8539} L}{247{,}960\ d^{4.8539}} \quad . . . . . (26)$$

or it may be expressed in terms of the diameter

$$d = \frac{Q^{.38194}}{12{,}923} \left[\frac{L}{(P_1^2 - P_2^2)} \right]^{.20602} \quad . . . . . (27)$$

● **Computation of a single line.** Problem No. 1: Find cubic feet per day delivery of a 24-in. (23.5-in. I.D.) pipe line 170 miles long, inlet 750 lb. gage pressure, outlet 400 lb.

By computation using equation (25):

$$Q = 812.36 \left[\frac{23.5^{2.6182} \times (764.4^2 - 414.4^2)^{.5394}}{170^{.5394}} \right]$$

$$= 812.36 \left(\frac{3888.03 \times 1069}{15.963} \right)$$

= 211.5 million cu. ft. per day.

By slide rule: Opposite 750 inlet gage pressure set 400 outlet pressure. At arrow A read 1069, the value of $(P_1^2 - P_2^2)^{.5394}$ Opposite inside pipe diameter set length of line, then opposite 1069 (Scale F) pressure extension, read 211.5 million cu. ft. per day. The procedure can be reversed to find inlet and outlet pressure, the diameter can also be computed.

● **Computation of single lines with different diameters.** Where a single line consists of two or more different size diameter lines, the flow may be determined by first finding the equivalent length of the entire line in terms of a common diameter.

The flow of a given quantity of gas, Q, through two separate single lines of different diameter d_1 and d_2 and different lengths L_1 and L_2 under the same pressure and temperature conditions and same specific gravity and efficiency, by Equation (25) may be expressed as

$$Q = 812.36 \left(\frac{P_1^2 - P_2^2}{L_1} \right)^{.5394} d_1^{2.6182}$$

and $$Q = 812.36 \left(\frac{P_1^2 - P_2^2}{L_2} \right)^{.5394} d_2^{2.6182}$$

The values of Q, P_1, P_2 are the same in both equations, this becomes

$$\frac{d_1^{2.6182}}{L_1^{.5394}} = \frac{d_2^{2.6182}}{L_2^{.5394}}$$

$$\text{or } L_1 = L_2 \left(\frac{d_1}{d_2} \right)^{4.8539} \quad . . . . . (28)$$

where L_1 = the equivalent length of any pipe of length L_2 and diameter d_2 in terms of diameter d_1.

By rearranging equation (28)

$$d_1 = d_2 \left(\frac{L_1}{L_2} \right)^{.206} \quad . . . . . (29)$$

where d_1 = the equivalent diameter of any pipe of given diameter d_2 and length L_2 in terms of any other length L_1.

Problem No. 2: Find the cubic feet per day delivered through a system 50 miles long which consists of 40 miles of 22 in. (21.5 in. I.D.) and 10 miles of 16 in. (15.5 in. I.D.); inlet pressure 500 lb. gage; outlet pressure 200 lb. gage; specific gravity .60, temperature base and flow 60°F.; pressure base 14.735 lb. abs. and 92 per cent efficiency.

First determine the equivalent length of the 10 miles of 15.5 in. I.D. in terms of 21.5 in. I.D.

By computation using equation (28):

$$L_1 = 10 \left(\frac{21.5}{15.5} \right)^{4.8539}$$

L_1 = 48.95 of 21.5 in. I.D. The capacity of the system is equivalent to 48.95 + 40 or 88.95 miles of 21.5-in. I.D. pipe. The delivery is then computed as explained in problem 1.

By slide rule: Opposite 15.5 in. I.D. set 10 miles; then opposite 21.5 read 49 miles. The sum of these lengths is 49 + 40 or 89 miles.

● **Computation of per cent increase in capacity by partial looping with same diameter line.** The equivalent length Le, for use in calculating the flow of gas through parallel lines of different diameters d and d_1 of actual length L_a with the same inlet and outlet pressures, temperature, gravity, pressure and temperature base and efficiency, is obtained as follows:

$$Q = K \frac{d^{2.6182}}{L_a^{.5394}} \quad . . . . . (30)$$

$$Q_1 = K \frac{d_1^{2.6182}}{L_a^{.5394}} \quad . . . . . (31)$$

where K is the constant, Q = volume through line d and Q_1 = volume through line d_1 both of length L_a.

Adding equations (30) and (31) the volume through both lines becomes

$$Q + Q_1 = \frac{K}{L_a^{.5394}} (d^{2.6182} + d_1^{2.6182}) \quad . . . . . (32)$$

The equivalent length L_e in terms of diameter d, which has the same capacity of the two parallel lines, is expressed thus:

$$Q + Q_1 = K \frac{d^{2.6182}}{L_e^{.5394}} \quad . . . . . (33)$$

Dividing equation (33) by equation (32)

$$\frac{Q + Q_1}{Q + Q_1} = \frac{K\, d^{2.6182}}{L_e^{.5394}} \times \frac{L_a^{.5394}}{K (d^{2.6182} + d_1^{2.6182})} \quad . . . (34)$$

$$1 = \left(\frac{L_a}{L_e} \right)^{.5394} \left(\frac{d^{2.6182}}{d^{2.6182} + d_1^{2.6182}} \right) \quad . . . . . (35)$$

$$L_e^{.5394} = L_a^{.5394} \left(\frac{d^{2.6182}}{d^{2.6182} + d_1^{2.6182}} \right) \quad . . . . . (36)$$

$$L_e = L_a \left(\frac{d^{2.6182}}{d^{2.6182} + d_1^{2.6182}} \right)^{1.8539} \quad . . . . . (37)$$

where L_e is the equivalent length of any two parallel lines of length L_a of diameters d and d_1 in terms of diameter d.

If the diameters d and d_1 are equal

$$L_e = L_a \left(\frac{1}{2} \right)^{1.8539} \quad . . . . . (38)$$

$$L_e = .27664\ L_a \quad . . . . . (39)$$

From equation (39), to loop lines of equal diameter has the effect of shortening the actual length by (1 — .27644) or .72336 miles per mile of parallel line.

If X, expressed decimally, be the portion of original line paralleled, the ratio of the capacity Q_1 after partial paralleling to the capacity Q before paralleling, with a line of equal diameter, is:

$$\frac{Q_1}{Q} = \left(\frac{1}{1 - .72336\,X} \right)^{.5394} \quad . . . . . (40)$$

$$\text{or } Q_1 = Q \left(\frac{1}{1 - .72336\,X} \right)^{.5394} \quad . . . . . (41)$$

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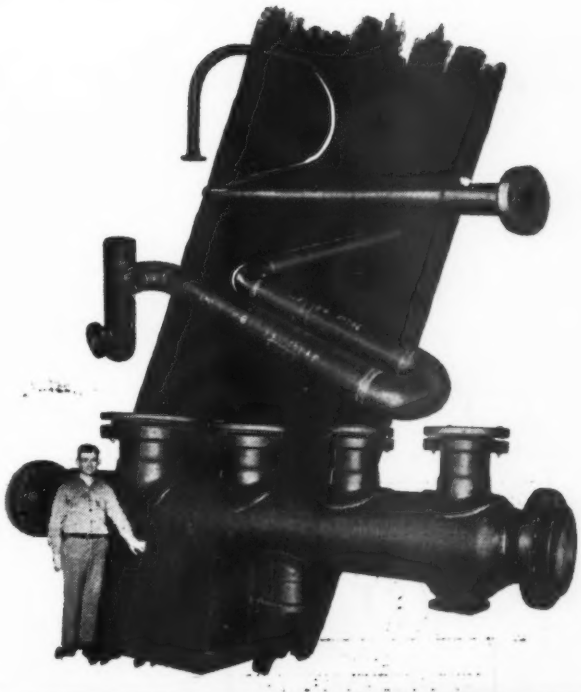

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$\left(\frac{Q_1 - Q}{Q}\right) 100$ = per cent increase in capacity.

Problem No. 3: Find the increase in capacity of any line if looped 50 per cent of its length with the same size diameter line.

By computation using equation (41):

$$Q_1 = Q \left[\frac{1}{1 - (.72336 \times .50)}\right]^{.5394}$$

$$Q_1 = 1.274\,Q$$

Let Q = 1.00 capacity before looping, then $Q_1 = 1.274$

$\left(\frac{Q_1 - Q}{Q}\right) 100$, or $\left(\frac{1.274 - 1.00}{1.00}\right) 100$

= 27.4 per cent increase in capacity.

By slide rule: Set Scales D and DL to coincide.

Opposite 50 per cent of line looped (Scale H) read 27.4 per cent increase in capacity on Scale G.

● **Computation of per cent increase in capacity by partial looping with different size diameter line.** The total length (L) of a system minus the length of the paralleled section, plus the equivalent length (L_e) of the paralleled section in terms of the diameter of the original line d, is equal to the length L_{es} of a single line of diameter d, which is equivalent to the entire system after X fraction has been paralleled, or

$$L_{es} = (L - XL) + L_e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (42)$$

By equation (37)

$$L_e = XL \left(\frac{d^{2.6182}}{d^{2.6182} + d_1{}^{2.6182}}\right)^{1.8539} \quad . \quad . \quad . \quad . \quad . \quad . \quad (43)$$

Substituting equation (43) in equation (42)

$$L_{es} = (L - XL) + XL \left[\frac{d^{4.8539}}{(d^{2.6182} + d_1{}^{2.6182})\,1.8539}\right] . \quad (44)$$

By the Panhandle formula

$$Q_1 = 812.36 \frac{(P_1{}^2 - P_2{}^2)^{.5394} d^{2.6182}}{L^{.5394}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

For the same equation after paralleling

$$Q_1 = 812.36 \frac{(P_1{}^2 - P_2{}^2)^{.5394}\, d^{2.6182}}{L_{es}{}^{.5394}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (45)$$

from which $\frac{Q_1}{Q} = \left(\frac{L}{L_{es}}\right)^{.5394}$ . . . . . (46)

and $L_{es} = L \left(\frac{Q}{Q_1}\right)^{1.8539}$ . . . . . (47)

Substituting the value of L_{es} from equation (47) into equation (44)

$$L \left(\frac{Q}{Q_1}\right)^{1.8539} = (L - XL) + (XL) \left[\frac{d^{4.8539}}{(d^{2.6182} + d_1{}^{2.6182})\,1.8539}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (48)$$

Simplifying and solving equation (48) for X and Q, the following equations are obtained:

$$X = \frac{\left[\left(\frac{Q}{Q_1}\right)^{1.8539}\right] - 1}{\left[\frac{d^{4.8539}}{(d^{2.6182} + d_1{}^{2.6182})\,1.8539}\right] - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (49)$$

and

$$Q_1 = \frac{Q}{\left(X \left\{\left[\frac{d^{4.8539}}{(d^{2.6182} + d_1{}^{2.6182})\,1.8539}\right] - 1\right\} + 1\right)^{.5394}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (50)$$

where Q_1 is the capacity of parallel lines of diameters d and d_1 with X (decimal) amount paralleled when Q = capacity of original line d.

The value of d and d_1 in equations (49) and (50) may be expressed as a ratio.

Dividing the numerator and denominator of the term $\left[\frac{d^{4.8539}}{(d^{2.6182} + d_1{}^{2.6182})\,1.8539}\right]$ in equations (49) and (50), by $d^{4.8539}$ we have

$$\frac{1}{\left(\frac{d^{2.6182}}{d^{2.6182}} + \frac{d_1{}^{2.6182}}{d^{2.6182}}\right)^{1.8539}} = \frac{1}{\left[1 + \left(\frac{d_1}{d}\right)^{2.6182}\right]^{1.8539}} \quad . \quad (51)$$

Substituting $\frac{1}{\left[1 + \left(\frac{d_1}{d}\right)^{2.6182}\right]^{1.8539}}$

in equation (49) and (50)

$$X = \frac{\left[\left(\frac{Q}{Q_1}\right)^{1.8539} - 1\right]}{\left\{\frac{1}{\left[1 + \left(\frac{d_1}{d}\right)^{2.6182}\right]^{1.8539}}\right\} - 1} \quad . \quad . \quad . \quad . \quad . \quad (52)$$

APPENDIX 1—TABLE NO. 1*

Tennessee Gas and Transmission Corporation

Abs. P_1	Press. P_2	Inside diam. I.D.	Length in miles L	Metered volume † 14.735 lb. abs. & 60°F.	Calculated by Panhandle formula E=.92 14.735 lb. abs. & 60°F.	E factor	Actual $\sqrt{\frac{1}{f}}$	Reynolds number, thousands §
774.4	372.4	23.50	161.876	231246	232610	91.46	20.706	11228
761.4	359.4	23.50	157.810	228590	233681	90.00	20.381	11099
742.4	354.4	23.50	156.564	226178	227530	91.45	20.645	10982
774.4	394.4	23.4375	173.923	223269	219875	93.42	21.073	10870
759.4	390.4	23.4375	166.922	220835	220494	92.14	20.784	10751
770.4	372.4	23.50	179.128	219244	222401	90.69	20.463	10646
742.4	391.4	23.50	180.273	206810‡	206674	92.06	20.672	10042
			1176.496		Average	91.75		

*Federal Power Commission Docket G-621 Exh. to Application Sec. 2 T. G. & T. Co.
†Corrected for specific gravity and temperature at 14.735 lb. abs.
‡Equivalent flow calculated, gas metered from this section.
§1.934 (QG)÷d where Q=volume at 14.735 lb. abs. and 60°F.

TABLE NO. 2*. Cities Service Pampa-Wichita Line

Abs. P_1	Press. P_2	Inside diam. I.D.	Length in miles L	Metered volume 14.735 lb. abs. & 60°F.	Calculated by Panhandle formula E=.92 14.735 lb. abs. & 60°F.	E factor	Actual $\sqrt{\frac{1}{f}}$	Reynolds number, thousands †
				Section 1				
376	252	19.375	57.2	89997	88392	93.67	20.51	6234
373	216	19.375	57.2	98491	97017	93.40	20.59	6823
400	232	19.375	57.2	104963	104526	92.38	20.48	7271
402	231	19.375	57.2	106580	105618	92.84	20.59	7383
396	227	19.375	57.2	104963	104052	92.81	20.56	7271
324	163	19.375	57.2	90300	88756	93.60	20.50	6256
321	194	19.375	57.2	80795	80487	92.35	20.09	5597
361	207	19.375	57.2	95255	94152	93.08	20.47	6599
384	188	19.375	57.2	107794	107639	92.13	20.47	7467
405	180	19.375	57.2	117603	117369	92.18	20.61	8147
404	178	19.375	57.2	117906	116616	93.02	20.67	8168
391	183	19.375	57.2	111738	111353	92.32	20.56	7741
					Average	92.83		
				Section 2				
380	266	19.375	56.0	89289	86788	94.65	20.69	6185
389	251	19.375	56.0	97682	95725	93.88	20.67	6767
407	259	19.375	56.0	104255	101565	94.44	20.88	7222
414	264	19.375	56.0	105772	103293	94.21	20.86	7327
413	264	19.375	56.0	104052	102840	93.08	20.61	7208
360	230	19.375	56.0	89491	88712	92.81	20.33	6199
344	242	19.375	56.0	79176	77548	93.93	20.37	5485
376	242	19.375	56.0	94446	92458	93.98	20.64	6543
394	226	19.375	56.0	106682	104634	93.80	20.79	7390
421	232	19.375	56.0	116389	114661	93.39	20.84	8063
420	231	19.375	56.0	116187	114469	93.38	20.83	8049
405	222	19.375	56.0	110828	110240	92.49	20.58	7678
					Average	93.67		

Specific gravity=.694. Viscosity=7 × 10-6
*Benjamin Miller "Part reprinted from Transcript American Institute of Chemical Engineers vol. 32, p. 9, 1936".
†1.934 (QG)÷d where Q=volume at 14.735 lb. abs. and 60°F.

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TABLE 3. Test data on flow of

Line	Test no.	Location of line	Description of pipe: O.D., in.	I.D., in.	Wt. per ft., lb.	Length of line tested, miles	Type of joint	Length of test period: hr.	min.	Specific gravity of gas: air=1	Temp. of flowing gas, °F.	Barometric pressure, lb. per sq. in.: Inlet	Outlet	Pressures lb. per sq. in. abs.: Average inlet pressure (P_1)	Diff. between initial and final P	Average outlet pressure (P_2)	Diff. between initial and final P_2	P_1-P_2	Volumes, 1000 cu. ft. per hr. at 14.4 lb. per sq. in. abs. and 60°F.: Metered inlet	Metered outlet	Calculated from Weymouth's formula
1	1	Texas	22.00	21.380	72.383	38.02	Coupled	1	00	0.593	63.0	14.67	14.88	174.15	+0.7	162.13	+0.5	12.02	1,359	1354	1345
	2							1	00	.599	64.0	14.55	14.82	167.62	−0.7	162.60	−0.9	5.02	859	903	856
2	1	Texas	18.00	17.500	47.393	34.73	Coupled		44	.597	74.0	14.64	14.71	151.71	−0.2	139.29	−0.2	12.42	770	774	769
	2								40	.597	72.5	14.65	14.72	161.57	−0.5	151.49	−0.3	10.08	721	734	720
3	1	Texas	18.00	17.438	53.223	27.047	Coupled		50	.746	55.6	14.30	14.30	302.34	−0.2	281.13	+0.3	21.21	1,368	1368	1455
	2								59	.746	55.6	14.39	14.38	312.99	−4.4	288.80	−4.4	24.19	1,445	1536	1578
	3							2	00	.740	55.0	14.23	14.23	259.33	−7.6	230.22	−7.7	29.11	1,483	1561	1568
	4							1	00	.743	54.7	14.50	14.51	250.58	−1.0	223.42	−0.7	27.16	1,429	1454	1489
	5								48	.750	56.0	14.32	14.32	331.46	+2.0	317.07	+2.0	14.39	1,180	1133	1259
4	1	Okla.	16.00	15.50	42.053	18.208	Coupled	2	00	.794	61.4	14.21	14.21	200.66	−0.2	192.87	+0.1	7.79		499	621
	2							1	00	.796	62.0	14.07	14.07	219.74	−0.4	212.84	−0.5	6.90		498	612
5	1	Okla.	16.00	15.432	47.669	22.758	Welded	1	5	.769	62.2	14.29	14.29	163.74	+0.3	151.19	+0.3	12.55	650	652	633
	2							1	00	.772	63.0	14.22	14.10	136.17	+1.0	122.80	+1.0	13.37	606	601	591
	3							1	00	.768	62.6	14.22	14.15	136.75	−1.5	121.62	−1.7	15.13	631	662	630
6	1	Okla.	16.00	15.375	52.579	11.534	Coupled	1	00	.806	72.0	14.38	14.37	230.52	−2.6	228.81	−2.7	1.71		354	380
	2							1	00	.806	69.0	14.37	14.39	230.88	+1.8	229.99	+1.8	0.89		269	275
7	1	Calif.	15.00	14.50	39.41	32.51	Welded		56	.635	62.0	14.76	14.34	364.52	−0.3	221.28	−0.3	143.24		2240	2275
	2							1	00	.633	61.5	14.83	14.37	353.99	+3.1	209.07	+3.1	144.92		2210	2248
8	1	Texas	14.000	13.500	36.713	59.586	El. weld B&S	1	00	.573	63.0	14.29	14.64	409.40	+0.2	374.88	0.0	34.52	929		830
	2								36	.573	62.0	14.30	14.66	408.88	+0.1	374.61	0.0	34.27	927		827
9	1	Ohio	16.000	15.250	62.579	31.390	Coupled		52	.667	59.0	14.41	14.28	52.03	−1.0	44.93	−0.9	7.10	152	169	166
	2		12.750	12.125	41.51	7.707			36	.661	62.0	14.36	14.29	36.68	−0.2	31.22	−0.4	5.46	113	117	122
	3		12.750	12.125	41.51	5.882*			28	.661	60.5	14.38	14.34	38.77	−0.8	33.81	−0.8	4.96	95	130	121
9A	1	Ohio	16.000	15.250	62.579	31.390	Coupled														
			12.750	12.125	41.51	5.882*			52	.667	59.0	14.34	14.28	49.18	−0.9	44.93	−0.9	4.25		169	166
9B	1	Ohio	12.750	12.125	41.51	7.707	Coupled		36	.661	62.0	14.36	14.33	36.68	−0.2	34.03	−0.4	2.65	113		123
	2		12.750		41.51	5.882*			28	.661	60.5	14.38	14.39	38.77	−0.8	36.83	−0.9	1.94	95		109
9C	1	Ohio	16.000	15.250	62.579	31.390	Coupled		36	.661	62.0	14.33	14.29	34.03	−0.4	31.22	−0.4	2.81		117	121
	2								28	.661	64.0	14.39	14.34	36.83	−0.9	33.81	−0.8	3.02		130	131
9D	1	Ohio	12.750	12.125	41.51	7.707	Coupled		52	.667	59.0	14.41	14.34	52.03	−1.0	49.18	−0.9	2.85	152		166
10	1	Calif.	12.75	12.3125	29.44	49.955	Welded		52	.635	53.0	14.88	14.30	375.39	−0.4	143.32	−0.4	232.07		1431	1434
	2								56	.639	54.7	14.77	14.23	375.61	−3.6	146.43	−3.5	229.18		1451	1423
11	1	Texas	12.75	12.25	33.375	18.423	Coupled		52	.564	79.5	14.76	14.64	464.36	0.0	423.51	0.0	40.85		774	1323
	2								52	.564	79.5	14.76	14.66	470.98	−1.6	427.70	−1.6	43.29		799	1370
12	1	Texas	12.75	12.188	37.453	65.962	Coupled		50	.569	82.0	14.27	14.54	458.26	0.0	323.23	0.0	135.03	1349		1169
	2							1	00	.569	82.4	14.30	14.55	457.39	−0.4	313.10	−1.2	144.29	1381		1199
13	1	Texas	12.75	12.188	37.453	24.644	Coupled	1	00	.562	75.0	14.89	14.82	486.30	−1.2	482.53	−1.2	3.77		346	360
	2							1	00	.562	74.8	14.90	14.84	487.50	−0.5	483.80	−0.5	3.70		341	357
13A	1	Texas	12.75	12.188	37.453	18.015	Coupled	1	00	.562	75.0	14.85	14.79	465.64	−0.1	463.97	−0.1	1.67		257	274
	2							1	00	.562	75.0	14.82	14.74	471.44	+2.7	469.07	+2.7	2.37		309	328
14	1	W. Va.	12.750	12.125	41.51	11.35	Coupled	1	00	.672	73.5	14.41	14.29	84.72	−0.2	77.52	−0.3	7.20		140	271
	2								52	.672	74.0	14.41	14.29	87.63	0.0	80.46	0.0	7.14		143	275
15	1	Pa.	12.750	12.125	41.51	10.95	Coupled	1	00	.627	61.5	13.86	13.79	206.04	0.0	204.80	0.0	1.15	89		184
	2								20	.627	61.6	13.86	13.78	206.14	0.0	204.98	0.0	1.16	89		185
16	1	Kan.	12.75	12.090	43.77	16.402	Welded	1	00	.962	75.0	14.24	14.18	155.34	+1.2	138.51	−0.3	16.83		399	384
	2							1	00	.962	75.0	14.24	14.18	154.01	+1.9	137.61	+1.6	16.40		383	378
	3								35	.962	75.0	14.24	14.17	127.98	−2.1	122.09	−2.0	5.89		205	210
17	1	Calif.	10.75	10.250	28.035	18.439	Welded		48	.688	62.0	14.18	14.34	248.42	−11.6	202.47	−11.4	45.95		507	572
	2					16.320			32	.675	59.5	13.97	14.19	224.03	0.0	210.97	−0.2	13.06		197	322
18	1	Okla.	10.75	10.250	28.035	7.38	Coupled		55	.888	65.0	14.37	14.37	200.52	+0.1	188.08	+0.1	12.44		199	383
	2								50	.893	67.0	14.29	14.29	177.08	+0.4	164.22	−0.3	12.86		191	363
19	1	La.	10.75	10.192	31.201	9.83	Screwed	1	12	.617	57.5	14.60	14.57	586.91	0.0	566.37	0.0	20.54		839	875
	2							1	00	.617	55.8	14.61	14.59	596.15	−1.1	575.44	−0.9	20.71		867	887
20	1	La.	10.75	10.192	31.201	61.22	Screwed		20	.637	65.8	14.85	14.73	581.25	0.0	415.93	0.0	165.32	821		925
	2	and						1	00	.637	64.5	14.80	14.67	596.75	−7.8	459.28	−8.7	137.47	714		869
	3	Ark.							40	.637	66.2	14.85	14.73	580.31	−0.8	416.08	+0.4	164.23	821		921
21	1	Pa.	10.00	9.625	19.649	21.08	Coupled	1	00	.603	66.5	13.96	13.82	114.08	−1.3	108.35	−1.2	5.73		125	119
	2								40	.603	66.5	13.82	13.82	112.99	−0.8	107.38	−0.7	5.61		122	118
22	1	Calif.	8.625	8.125	22.361	8.224	Welded	1	12	.692	72.5	14.32	14.77	164.10	+0.8	94.35	+0.8	69.75	447		424
	2								40	.692	68.7	14.29	14.72	102.27	−3.5	74.29	−3.7	27.98	232		223
23	1	Calif.	8.625	8.125	22.361	11.867	Welded	1	00	.709	56.5	14.88	14.79	152.05	−2.2	109.65	−2.0	42.40		295	278
	2					12.724		1	00	.710	62.0	14.84	14.81	134.91	+4.0	92.68	+4.2	42.23		260	248
24	1	N. Y.	8.625	8.071	24.696	25.56	Coupled	1	00	.589	63.5	14.05	14.09	88.53	−1.4	82.28	−1.1	6.22		68	63
	2								56	.589	65.0	14.07	14.09	90.00	+0.3	83.69	+0.3	6.31		60	64
25	1	Mont.	8.625	7.981	29.350	24.46	Screwed		44	.666	70.0	12.43	12.72	144.25	−0.5	138.19	−0.5	6.06	80		74
	2							1	00	.666	70.5	12.42	12.71	142.40	−1.1	136.52	−1.1	5.88	77		72
26	1	Calif.	6.625	6.185	15.049	1.904	Welded		56	.719	56.5	14.57	12.74	290.53	−0 7	160.91	−0.7	129.62	419		361
	2		8.625	8.125	22.361	7.750			52	.721	56.0	14.51	12.60	292.08	−0.8	181.62	−0.6	110.46	391		342
			8.625	8.185	19.748	21.432															
27	1	Kan.	8.625	8.063	25.062	3.517	Welded	1	29	.710	67.2	13.98	14.06	113.00	−2.5	89.68	−4.0	23.32		85	75
	2		6.625	6.125	17.021	14.303		1	00	.708	74.0	13.98	13.98	125.71	−1.2	106.78	−1.4	18.93		80	72
27A	1	Kan.	8.625	8.063	25.062	3.517	Welded	1	00	.710	66.8	14.14	14.20	143.05	−0 7	141 83	−0.7	1.22		83	88
	2								40	.710	65.2	14.13	14.16	147.71	−3.1	146.45	−2.9	1.26		86	91
27B	1	Kan.	6.625	6.125	17.021	14.303	Welded	3	52	.708	67.0	13.98	14.09	126 87	−2.4	107.07	+0.7	19.80		86	76
	2							1	00	.708	72.5	13.98	14.09	127.09	−0.4	107.52	−0.3	19.57		86	76
	3								40	.710	67.0	13.89	14.02	151.23	−0.9	133.43	+0.4	17 80		89	80
28	1	Wyo.	6.625	6.250	12.891	20.546	Welded	1	00	.580	80.0	11.88	12.30	116.27	+1 0	113.34	+1.0	2.93	30.0		28
	2							1	00	.580	84.0	11.86	12.25	102.76	−0.8	101.27	−0.8	1.49	19.2		18.7
29	1	Okla.	6.625	6.04	19.75	11.944	Welded		30	1.044	75.0	14.18	14.20	202.90	−0.5	167.10	−0.7	35.80	129		111
	2								15	1.058	81.0	14.09	14.11	213.64	+0.1	169.86	+0.1	43.78	147		124
	3								45	1.040	75.0	14.20	14.20	205.17	−0.5	166.35	+0.1	39.82	136		116

†The left 25 columns of this table are a reprint of Table 4, U. S. Department of Interior, Bureau of Mines Monograph 6 "Flow of Natural Gas Through High-Pressure Lines." The right 8 columns have been added for comparison.

*This section paralleled with 12.750-in.

gas through pipe lines†

Percentage difference from Weymouth's formula		Remarks	1000 cu. ft. per day at 14.735 lb. abs.			Actual value of E by Panhandle formula	Actual coefficient of Friction△	Reynolds number $1.934 \frac{QG^{\blacklozenge}}{d}$	Test No.	Line No.
Inlet	Outlet	Note: N = less than 0.25 per cent	metered volume†	Calculated from Weymouth formula‡	Calculated from Panhandle formula (E = .92)					
+ 1.0 + 0.5	+ 0.5 + 5.5	Uniform flow conditions. Line traverses flat country.	31816	31546 Large difference in meter readings. Low rate.	30628	95.57	18.79	1707000	1 2	1
N N	+ 0.5 + 2.0	Uniform flow conditions. Line traverses flat country.	18107 17063	18036 16887	17668 16447	94.29 95.45	18.07 18.20	1195000 1126000	1 2	2
− 6.0 − 8.5	− 6.0 − 2.5	Line traverses rolling plains.	32086	34126 Gas withdrawn from line, unsteady flow (p. 25)•	35787	82.49	16.93	2655000	1 2	3
− 5.5 − 4.0 − 6.5	− 0.5 − 2.5 −10.0	Wide range of flow conditions.	33810	Gas withdrawn from line, unsteady flow (p. 25)• 34924 Gas stored in line (p. 25)•	36957	84.17	17.44	2786000	3 4 5	
	−19.5 −18.5	Rust and condensate in the pipe line. Traverses hilly country.		Rust and condensate in line (p. 66)• Rust and condensate in line (p. 66)•					1 2	4
+ 2.5 + 2.5 N	+ 3.0 + 1.5 + 5.0	Uniform flow conditions. Line traverses hilly country.	15269 14155 15163	14847 13862 14776	15096 14015 15009	93.05 92.92 92.94	18.13 18.02 18.11	1472000 1369000 1459000	1 2 3	5
	− 7.0 − 2.0	Delivery was small.		Pressure changed during test. Low rate. (p. 27)• Pressure changed during test. Low rate. (p. 27)•					1 2	6
	− 1.5 − 1.5	Large delivery. Line traverses mountainous country.	52538 51834	53359 52725	60054 59272	80.49 80.45	17.19 17.16	4450000 4376000	1 2	7
+12.0 +12.0		Appreciable difference in elevation between two ends; correction applied.	21789 21742	19467 19397	20438 20368	98.08 98.21	19.32 19.34	1789000 1785000	1 2	8
− 8.5 − 7.5 −21.5	+ 2.0 − 4.0 + 7.5	This line consists of 7.707 miles of 12.750-in., 5.882 miles of 12.750-in. paralleled with 12.750-in. and 31.39 miles of 16.000-in. Pressures taken at inlet and outlet also at junction of 16-in. with double 12-in. and later at junction of single 12-in. with double 12-in.	3764 2697	3891 2861 Large difference in meters. Low rate.	3624 2596	95.55 95.58	16.91 16.49	400000 284000	1 2 3	9
	+ 2.0			Gas withdrawn during test. Low rate.					1	9A
− 8.0 −13.0				Meter pulsation. Low rate. (pp. 18 and 104)• Meter pulsation. Low rate. (pp. 18 and 104)•					1 2	9B
	− 3.5 − 1.0	Delivery was small.		Low rate of flow. (pp. 18 and 104)• Low rate of flow. (pp. 18 and 104)•					1 2	9C
− 8.5				Meter pulsation. Low rate. (pp. 18, 27 and 104)•					1	9D
	N + 2.0	Line traverses semirugged country.	33563 34032	33634 33376	38066 37764	81.12 82.91	16.96 17.32	3348000 3416000	1 2	10
	−41.5 −41.5	Condensate in pipe line. Line traverses rolling plains.		Water in line. (p. 53)• Water in line. (p. 53)•					1 2	11
+15.5 +15.0		Line traverses rolling plains.	31640 32391	27418 28122	30346 31199	95.92 95.52	19.57 19.54	2857000 2925000	1 2	12
	− 4.0 − 4.5	Traverses flat country. Section 13 includes 13A.		Low rate of flow. Low rate of flow.					1 2	13
	− 6.0 − 6.0	Line in operation three days before test was made.		Low rate of flow. Low rate of flow and change in pressure. (p. 27)•					1 2	13A
	−48.5 −48.0	This line started at a charcoal gasoline plant. Gas carried fluid.		Large amount of water in line. (p. 54)• Large amount of water in line. (p. 54)•					1 2	14
−51.5 −52.0		Line started at discharge of gasoline plant. Rust and condensate in line.		Rust scale and liquid in line. (pp. 66 and 106)• Rust scale and liquid in line. (pp. 66 and 106)•					1 2	15
	+ 4.0 + 1.5 − 2.5	Line traverses flat prairie country.	9358 8983 4808	9006 8866 4925	9551 9378 4969	90.14 88.12 89.02	17.59 17.18 16.57	1441000 1382000 740000	1 2 3	16
	−11.5 −39.0	Condensate in line. Traverses rugged country for half its length.		Oil and water in line. (pp. 54 and 106)• Oil and water in line. (pp. 54 and 106)•					1 2	17
	−48.0 −47.5	Rust scale in pipe. Line traverses flat country.		Rust scale in line. (pp. 66 and 106)• Rust scale in line. (pp. 66 and 106)•					1 2	18
	− 4.0 − 2.5	Line traverses low rolling country. Originally laid as an oil line but never used as such.		Line 19 and 20 tested to 500 lb. hydraulic pressure, probably water in line. See pages 106 and 107.					1 2	19
−11.0 −18.0 −11.0				See line 19. See line 19. See line 19.					1 2 3	20
	+ 5.0 + 3.5	This line was of wrought iron, approximately 30 years old.	2932 2861	2791 2768	2763 2720	97.63 96.77	17.02 16.89	355000 347000	1 2	21
+ 5.5 + 4.0		Line traverses flat country. Pressure at inlet very unsteady.	10484 5441	9945 5230	11477 5731	84.04 87.34	17.19 16.49	1727000 896000	1 2	22
	+ 6.0 + 5.0	Line traverses flat country.	6919 6098	6520 5817	7286 6453	87.37 86.94	16.83 16.61	1168000 1031000	1 2	23
	+ 8.0 − 6.0	Newly completed line.		Gas withdrawn during test. Low rate. Gas stored during test. Low rate.					1 2	24
+ 8.0 + 7.0		Large difference in elevation between two ends; correction applied.		Gas withdrawn during test. Low rate. Gas withdrawn during test. Low rate.					1 2	25
+16.0 +14.5		Large difference in elevation between inlet and outlet; correction applied.	9827 9171	8467 8021	9815 9234	92.11 91.37	18.14 17.91	1669000 1156000	1 2	26
	+13.5 +11.0	Line 27 consists of lines 27A and 27B.		Gas withdrawn during test. Low rate. Gas withdrawn during test. Low rate. (p. 27)•					1 2	27
	− 5.5 − 5.5			Low rate of flow. Low rate of flow.					1 2	27A
	+13.0 +13.0 +11.5		2017 2017 2087	1783 1783 1876	1943 1922 2036	95.50 96.55 94.30	17.05 17.14 16.87	451000 451000 469000	1 2 3	27B
+ 7.0 + 2.5		Small delivery. Large difference in elevation; correction applied.		Low rate of flow. Low rate of flow.					1 2	28
+16.0 +19.0 +17.0		Line traverses rolling country.	3026 3448 3190	2603 2908 2721	3017 3388 3165	92.27 93.63 92.73	17.53 17.96 17.66	1011000 1168000 1062000	1 2 3	29

†Average of actual inlet and outlet metered volumes.
‡Computed from hourly rates in table.
•Pages referred to on this sheet are in Monograph 6.

△From Table 7, page 35 Monograph 6, where available.
◆Q = cu. ft. per day at 14.735 lb. abs.

Time-Saving Airco Processes fo

IN meeting the urgent need for speed during its wartime expansion, the petroleum industry has made ever-increasing use of both the oxyacetylene flame and the electric arc. These fast-working tools are providing valuable aid to the industry in many ways—in welding transmission pipe lines and refinery piping; in the fabrication, erection and alteration of structural units; in re-building and repairing worn and broken equipment of every type.

In addition to the processes shown on these pages, other Airco metal-working methods for the petroleum industry include: braze welding, hard facing, sil-brazing, scrap cutting, machine gas cutting, plate edge preparation, flame cleaning and dehydrating. Airco's Applied Engineering Department will provide information and assistance on any of these processes. For further details call or write any Airco office, or Dept. P. E. at the New York office.

Pipe Welding by use of electric arc or the oxyacetylene flame has played important part in helping industry keep pace with wartime expansion needs. Whichever method is used resulting joints are also stronger than the pipe itself

AIRCO

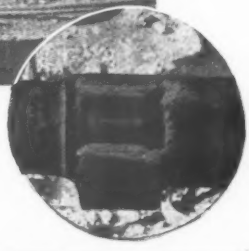
ses for Oil Field and Refinery

Flame Hardening sheaves with the oxyacetylene flame gives extra hardness in the cable grooves; prolonging their service life. Many types of equipment are made to last longer, wear better by flame hardening areas exposed to heavy wear.

Arc Welded Fabrication helps to meet emergency needs for pipe fittings not immediately available. Shop fabrication by this method is equally useful in reclaiming damaged equipment and in producing special equipment.

Airco Portable Pipe Cutting and Beveling Machine is widely used for removing frozen fittings as shown, and also for simultaneously cutting and beveling pipe before welding. Crank-operated, this handy machine makes fast, accurate cuts.

Structural Welding with the electric arc speeds the construction of storage tanks and many other units for oil field and refinery. This method saves both time and steel.



Flame Gouging is an important Airco process used for salvaging vital petroleum equipment. The close-up view shows how welded or shrunk-fit tool joints can be removed from drill pipe without damaging the drill pipe threads.

Oxyacetylene Flame Heating is the fast, modern method of heating pipe for bending, softening and straightening. Airco's new Multi-Flame Heating Tips provide an unusually high degree of localized heat to speed this type of work.

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TABLE 4. Friction factors

$$\sqrt{\frac{1}{f}} = KR^N$$

$\frac{R}{1.934}\frac{Qg}{d}$	Log R	N Log R	R^N	KR^N	.92 KR^N
Biddison and McKay $\sqrt{\frac{1}{f}}=5.87372\,R^{.077184}$					
100,000	5.000	.3859200	2.4318	14.2837	
300,000	5.4771213	.4227461	2.6470	15.5477	
1,000,000	6.000	.4631040	2.9047	17.0614	
3,000,000	6.4771213	.4999301	3.1618	18.5715	
10,000,000	7.000	.5402880	3.4697	20.3800	
30,000,000	7.4771213	.5771141	3.7767	22.1833	
Panhandle $\sqrt{\frac{1}{f}}=6.8719\,R^{.07305}$					
100,000	5.000	.3652500	2.3187	15.9339	14.6592
300,000	5.4771213	.4001037	2.5125	17.2656	15.8844
1,000,000	6.000	.4383000	2.7435	18.8531	17.3449
3,000,000	6.4771213	.4731537	2.9727	20.4281	18.7939
10,000,000	7.000	.5113500	3.2460	22.3062	20.5217
30,000,000	7.4771213	.5462037	3.5173	24.1705	22.2369

TABLE 5. Friction factors and Reynolds numbers.

f	$\sqrt{f}$	$\sqrt{\frac{1}{f}}$	Nikuradse a=4.0 b=−0.4 R	Drew & Genereaux a=3.2 b=1.2 R	Biddison a=3.62 b=−0.1 R
.0060	.077460	12.9099	27440	58920	50680
.0055	.074162	13.4840	39890	93020	76260
.0050	.070711	14.1421	61100	156650	121560
.0045	.067082	14.9071	100040	286320	208450
.0040	.063246	15.8113	178560	582110	392960
.0038	.061644	16.2222	232090	802690	523600
.0036	.060000	16.6667	307980	1135500	713730
.0034	.058310	17.1497	418490	1654000	998540
.0032	.056569	17.6775	584530	2492500	1439900
.0030	.054772	18.2575	842990	3907700	2150700
.0028	.052915	18.8982	1261700	6413700	3346100
.0026	.050990	19.6117	1974500	11121800	5466800
.0024	.048990	20.4123	3258200	20571500	9468300
.0022	.046904	21.3201	5738700	41335500	17617500
.0020	.044721	22.3609	10957500	91679500	35822000
.0019	.043589	22.9416	15704400	142848000	53174000
.0018	.042426	23.5705	23173500		
.0017	.041231	24.2536	35332600		
.0016	.040000	25.0000	55967500		

$$\frac{Q_1}{Q} = \left[X \left(\left\{ \frac{1}{\left[1 + \left(\frac{d_1}{d} \right)^{2.6182} \right]^{1.8539}} \right\} - 1 \right) + 1 \right]^{.5394} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (53)$$

$\left(\frac{Q_1 - Q}{Q}\right) 100$ = per cent increase in capacity.

Problem No. 4: Find the rate of flow of a 24-in. line (23.5 in. I.D.) delivering 100,000,000 cu. ft. per day if looped 60 per cent of its length with a 20-in. line (19.5 in. I.D.).

By computation using equation (56):

$$\frac{Q_1}{Q} = \left[.60 \left(\left\{ \frac{1}{\left[1 + \left(\frac{19.5}{23.5} \right)^{2.6182} \right]^{1.8539}} \right\} - 1 \right) + 1 \right]^{.5394}$$

$\frac{Q_1}{Q} = 1.2646$; per cent increase = 26.46 per cent.

$Q_1 = 1.2646 \times 100{,}000{,}000 = 126{,}460{,}000$ cu. ft.

By slide rule: Opposite 23.5 in. (Scale D) set 19.5 in. (Scale DL). At arrow (10 on Scale D) read .83 (at 8.3), which is the ratio of the diameter of the loop line to diameter of main line. Opposite arrow (Scale H) set .83 (Scale R); then opposite 60 per cent of line looped is 26.5 per cent increase in capacity (Scale G). Multiplication or division may be made by using Scales M and F as on any ordinary slide rule.

● **Computation of complex lines.** Problem No. 5: Find the equivalent in terms of a single line of 100 miles of 24-in. (23.5 in. I.D.) line of which 40 miles is looped with 20-in. (19.5 in. I.D.) and the remaining 60 miles is looped with 22-in. (21.5 in. I.D.) inlet pressure 600 lb. gage; outlet pressure 400 lb. gage; 0.60 specific gravity; temperature 60°F.; pressure base 14.735 abs.

This may be computed by first determining the equivalent length in terms of a single 23.5-in. I.D. line.

By computation using equation (37):

FIRST STEP—

$$L_e = 40 \left(\frac{23.5^{2.6182}}{23.5^{2.6182} + 19.5^{2.6182}} \right)^{1.8539}$$

$L_e = 16.48$ equivalent miles of single 23.5-in. line for first 40 miles of looped line.

SECOND STEP—

$$L_e = 60 \left(\frac{23.5^{2.6182}}{23.5^{2.6182} + 21.5^{2.6182}} \right)^{1.8539}$$

$L_e = 20.34$ equivalent miles of single 23.5-in. line for the remaining 60 miles of looped line.

The entire system is equivalent to the sum of these lengths (16.48 plus 20.34) or 36.82 miles of 23.5-in. I.D.

The final step to compute the rate of flow by the Panhandle formula by equation (25), which for the above condition may be expressed as

$$Q = 812.36 \frac{23.5^{2.6182} (614.4^2 - 414.4^2)^{.5394}}{36.82^{.5394}}$$

$= 331.7$ million cu. ft. per day.

By slide rule:

FIRST STEP—Opposite 23.5-in. I.D. (Scale D) set 19.5 (Scale DL). Opposite arrow at 10 (Scale D) reads .412 (Scale K). This is the equivalent miles of single 23.5-in. I.D. per mile of looping.

$40 \times .412 = 16.48$ equivalent miles of single 23.5-in. I.D.

SECOND STEP—Use same procedure, which is .339 equivalent miles of single 23.5-in. I.D. per mile of looped line.

$60 \times .339 = 20.34$ equivalent miles of 23.5-in. I.D.

The entire system is 16.48 plus 20.34 or 36.82 equivalent miles of single 24-in. The final step is the same slide rule procedure as in problem 1; the answer is 331.7 million cu. ft. per day.

The accuracy of the results obtained by slide rule will be found to be within 1 per cent of the calculated values.

The writer wishes to acknowledge his appreciation for the kind and able assistance rendered in the preparation of this article.

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IMPROVED FLUID PROCESS FOR CATALYTIC CRACKING

By E. V. MURPHREE,† C. L. BROWN,‡ E. J. GOHR,§ C. E. JAHNIG,§ H. Z. MARTIN,§ and C. W. TYSON§

DURING the past year a large number of fluid catalytic cracking plants of improved design have been put into commercial operation. These units, now producing large quantities of 100-octane gasoline and synthetic rubber raw materials, include major simplifications over the process as previously disclosed.[1,2]. This paper discusses general engineering features of the new design and the mechanics of its operation.

The fluid catalytic cracking process, which was originated by the Standard Oil Development Company and developed mainly by that organization, in essence comprises a new method of contacting gases and solids. In this technique the solid is handled as a fine powder and is suspended in the gas with which it is to be contacted. The solid material is maintained in a fluid, or freely flowing condition at all times and thus can be handled in much the same way as a liquid, although in contrast to liquid behavior the density of this "fluid" can be altered markedly by changing the solids to gas ratio or the flowing conditions.

Because of the vital part played by the fluid catalyst process in producing war products, it has been necessary to omit detailed information at many points in this paper.

● **Comparison of old and new method.** A comparison of the old and the new methods, which have been termed "upflow" and "downflow" operation, respectively, is shown in Fig. 1. In both cases pressure required for the flow of solid material from a low pressure source to a zone of higher pressure is attained by means of a standpipe. The fluid mixture enters the top of the standpipe in a fairly dense condition favorable to building up static pressure and as it passes down the standpipe its density tends to increase since the fluid is compressible. To avoid attainment of densities at which bridging and uneven flow would result, it is desirable to add aeration gas along the length of the standpipe.

In the downflow principle illustrated in the left-hand portion of Fig. 1, the finely divided solid material under elevated pressure at the base of the inlet solids standpipe flows through a control valve into an injection zone where it is diluted by a suitable gas stream and blown into the reactor. The velocity in the reactor is greatly decreased so that the solids tend to concentrate in the gas stream. Under these conditions the solids form a dense, turbulent bed having a relatively clearly defined level. The velocity in the vessel is sufficienty low and enough disengaging space is provided above the level so that only a small amount of solids passes overhead with the gas. The reaction vessel is made large enough to afford the required reaction time in the dense bed of fluidized solids, and the major portion of the solids fed to the reactor is withdrawn through a well to the outlet solids standpipe.

This may be compared with the older and previously disclosed upflow principle illustrated in the right-hand side of Fig. 1 wherein all the fluidized stream is taken overhead to dust recovery equipment. The advantages of the downflow arrangement are:

1. The problem of dust recovery has been materially reduced since only about 0.5 per cent of the circulating solids stream must be recovered.
2. The level of solids and consequently the degree of contact in the reactors can be set at will. In upflow operation the solids holdup is a function of numerous operating variables.
3. The height of the supporting structure is less, due to lower standpipe length because of less pressure drop in the fluidized solids circulation stream.
4. External hoppers are not needed since inventory changes are easily manipulated in the reaction vessels themselves.
5. The solids recovery equipment may be incorporated (in part at least) within the reaction vessels.

It is apparent from the above that the downflow system will provide lower investments as well as maintenance costs.

● **New design as applied to catalytic cracking.** Catalytic cracking of petroleum is essentially a two-stage operation. In the first step, the oil is contacted with the catalyst whereby the latter becomes fouled with coke. In the second stage, the catalyst must be burned free of this deposit. This is accomplished by the fluid process as a truly continuous operation in which the fluid catalyst is continuously circulated without mechanical means between the reaction and the regeneration stages.

Catalyst flow. Fig. 2 shows a flowsheet of a downflow type of fluid cracking unit that is now in wide use. Catalyst enters the regenerator well and flows down through the regenerated catalyst standpipe through a slide valve into the

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§Esso Laboratories, Standard Oil Development Co., Elizabeth, N. J.

FIG. 1.

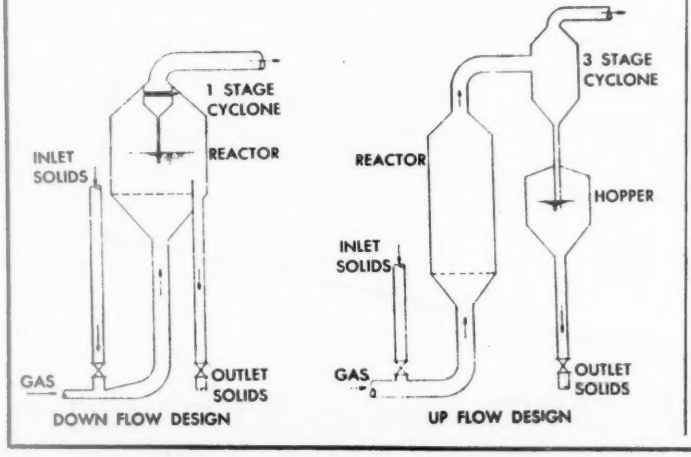
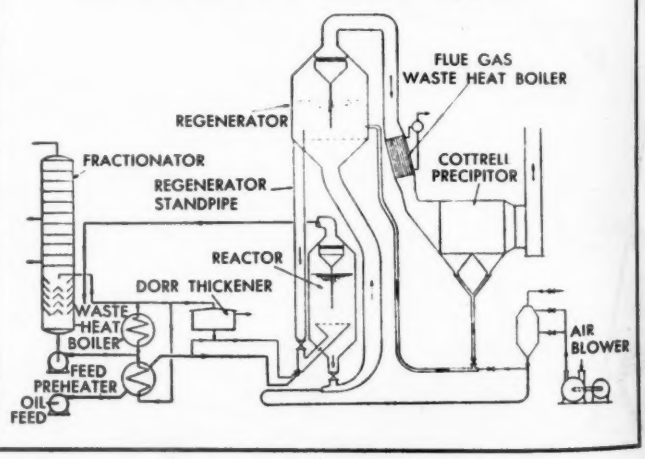


FIG. 2. Flow sheet of fluid cracking plant.



reactor inlet line. The particle size of the catalyst normally used may vary between 5 and 50 per cent on 100 mesh. The catalyst is mixed with the oil at this point at ratios of 5 to 30 lb. of catalyst per pound of oil, depending on the specific conditions employed. It will be noted that on this basis large quantities of catalyst must be circulated, corresponding to approximately 8 to 50 tons per min. for a 15,000 bbl. per day plant. From the injector the mixture flows upwards into the reactor where it mingles with the dense bed of fluid catalyst, which can be adjusted to such height as to obtain the degree of cracking desired. This vessel, in large fluid units, may have a diameter of 25 ft. and a height of 50 ft. with a holdup of fluidized, turbulent catalyst amounting to as much as 75 to 100 tons.

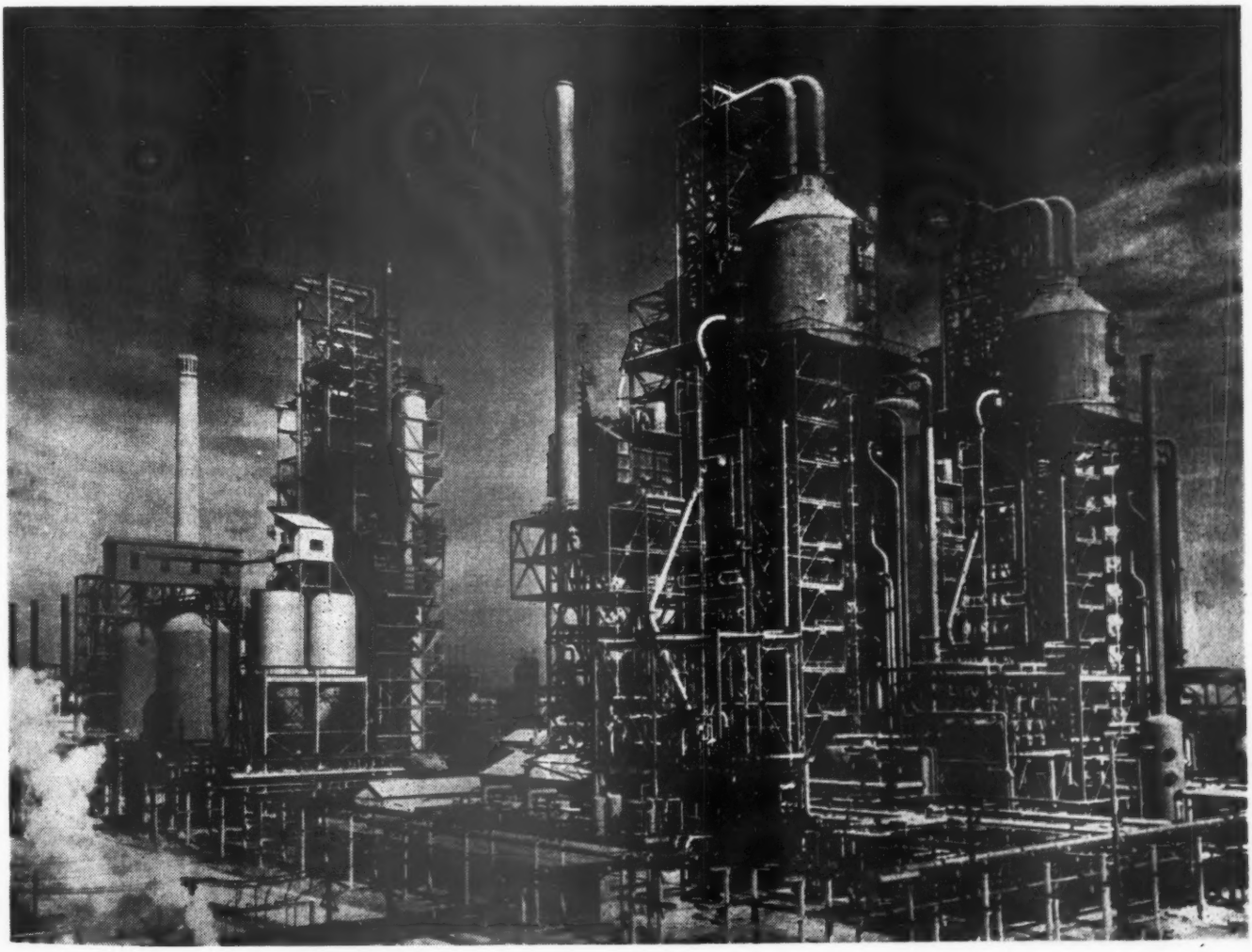
The catalyst leaving the fluidized reaction bed passes into the bottom of the vessel where it is stripped of hydrocarbon vapor with upflowing steam injected into the bottom of the vessel. From this stripping zone the solid flows into the spent catalyst standpipe, through a side valve for flow control and into a spent catalyst return line where it is mixed with air for regeneration and blown into the internally insulated regenerator. Here again the catalyst mixes in a dense fluid bed which is of such volume that sufficient time for the regeneration step is obtained. The regeneration vessels in 15,000 bbl. per day commercial fluid units ordinarily have a catalyst holdup of 150 to 300 tons. From this point the catalyst continues around the circuit again.

As brought out in discussing Fig. 1, high standpipe and low return line densities are maintained to facilitate catalyst circulation. High vessel densities make possible attainment of required reaction and regeneration contact times in reasonably sized equipment. It is of interest that the degree of settling of the finely powdered catalyst in the vessels is much greater than might be expected. For example, the average relative velocity of the catalyst with respect to the gas stream in the fluid existing in these vessels is found to be much greater than the velocity of free fall predicted by Stokes' Law.

Oil flow. The oil to be cracked is pumped from storage through a set of heat exchangers in which it is preheated by a fractionator bottom stream to a temperature that may be varied between 100 and 400°F. The stream of heated liquid feed, which may vary in boiling range from naphtha to heavy crude fractions, is injected into the stream of hot regennated catalyst leaving the regenerated catalyst slide valve. The regenerated catalyst is at a temperature of 1000° to 1150°F. and causes very rapid vaporization and heating of the charge stock to cracking temperatures of 800 to 1000°F. The fluid mixture flows into the reactor, which is ordinarily held at 8 to 12 lb. per sq. in. gage. Considerable flexibility in the severity of treatment is provided by simple regulation of the catalyst level in the reactor, or by change in the rate of catalyst circulation. Temperatures are uniform as a result of the heat capacity and turbulence of the fluidized catalyst mass.

The cracked product vapors leave the dense fluid catalyst bed and pass through a single stage of cyclone separators mounted in the upper head of the reaction vessel. In this equipment, the greater part of the small quantity of entrained catalyst particles is removed from the gas stream and returned through a dip pipe to a point well below the level of catalyst in the dense bed. This method of returning the recovered catalyst to the main circulating stream is simple and effectively prevents back flow of oil vapors.

The cracked products leave the top of the reactor and pass into the bottom of the fractionator. This tower is of conventional design for the most part and separates the products into a wet gas stream, light distillate, gas oil and cycle stock. The bottom of the tower below the usual bubble trays is fitted with 5



Three fluid catalyst cracking units in Baton Rouge refinery of Standard Oil Company of Louisiana. Two downflow units are on the right and pioneer upflow installation on the left.

disk and 4 donut trays over which a stream of heavy bottom product is circulated. This stream removes heat from the oil vapors, cooling them to 550 to 600°F. and is then passed through a series of heat exchangers where it gives up heat in part to the fresh feed, any excess being used to produce high pressure steam. In passing over the disk and donut section the circulating oil stream also scrubs out the remaining catalyst from the entering product stream and it is the resultant slurry of catalyst in heavy bottom product that is circulated over the disks and donuts and through the heat exchangers. The removal of dust from the vapors is virtually complete since no deposits are found on the bubble trays above the disks and donuts or in the side stream or overhead products.

A small portion of the circulating slurry stream is withdrawn for the recovery of the catalyst it contains. The quantity of this so-called "slurry return" is generally about 3 to 10 per cent of the fresh reactor charge and contains about 0.5 lb. of catalyst per gal. The catalyst concentration of the slurry is controllable and may be decreased by increasing the rate of slurry return. By maintaining slurry concentration below 0.5 lb. per gal., erosion of slurry pumps and valves is negligible.

Early practice was to send the slurry return directly to the reactor inlet line, which obviously meant cracking a portion of the heaviest oil product to extinction and consequently led to high carbon formation in the reactor. Slurry return is now sent to a Dorr thickener where about 70 per cent of the heavy oil is removed as a clarified oil containing less than 0.01 lb. of catalyst per gal. The thickened sludge containing most of the catalyst is mixed with fresh feed for dilution and pumped to the reactor inlet for recovery of the catalyst.

Air flow. The air-flue gas system starts the the turbo-blowers where air for regeneration is compressed to 13-15 lb. per sq. in. gage. Air flows through an auxiliary burner, used for starting up the plant, and then to the spent catalyst return line where it dilutes the solids flowing from the spent catalyst standpipe and enters the regenerator. Here the coke deposit on the spent catalyst is burned at a temperature of 1000-1150°F., the carbon content of the catalyst being reduced to less than 1 per cent and generally to about 0.5 per cent. Pressure in the regenerator is ordinarily maintained at 2 to 4 lb. per sq. in. gage. Resulting flue gases plus a small amount of entrained catalyst leave the dense bed of catalyst and pass through a single stage of cyclone separators where most of the catalyst is recovered and returned to the dense bed through a dip pipe as described in connection with the reactor. The hot flue gases then leave the regenerator containing a small quantity of catalyst and pass through a waste heat boiler where the gases are cooled to about 600°F. and by-product high pressure steam is produced. For a final cleanup, the flue gases are treated in a Cottrell electrical precipitator from which they are discharged to the atmosphere with a solid content of about 0.15 grains per

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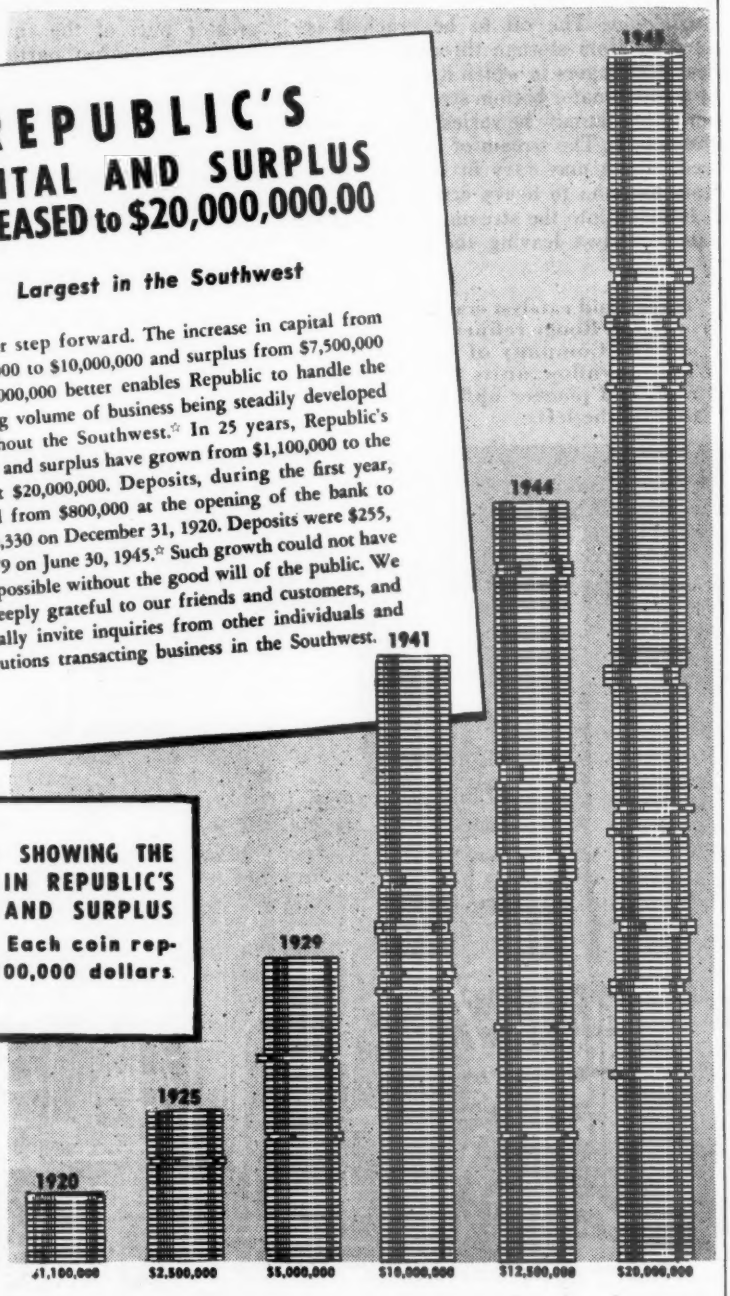

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FIG. 3. Overall heat balance.

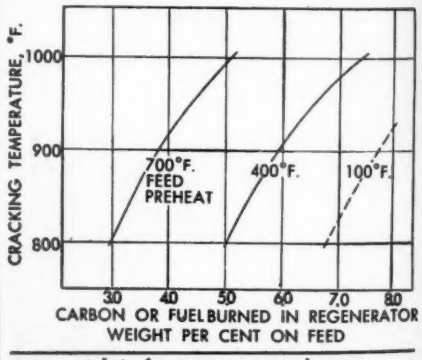
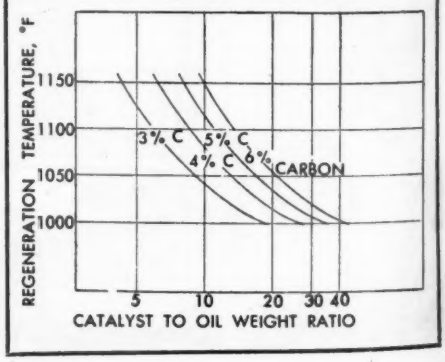
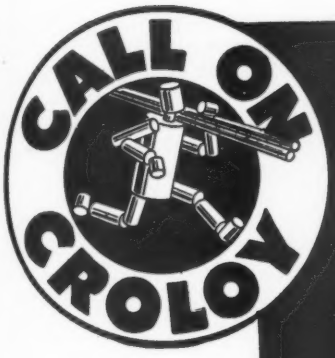


FIG. 4. Regenerator heat balance, 950°F. reactor.





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cu. ft. The fine catalyst recovered in the precipitator drops into a set of hoppers from which it is returned to the regenerator through a standpipe system.

Catalyst storage. Two storage hoppers are provided, each large enough to hold the entire plant inventory of catalyst. By imposing air pressure above the catalyst bed in the hoppers and operating them as blow-cases, catalyst may be added to the system at super-atmospheric pressure. The catalyst flows from the bottom of the storage hopper into a stream of air from the regeneration air blower and this mixture is introduced into the spent catalyst return line.

Catalyst can be removed from the base of the regenerated catalyst and Cottrell standpipes and conveyed in a stream of air to the storage hoppers. In order to avoid the necessity of designing the storage hoppers to withstand the high temperature conditions existing in the regenerator, the air-catalyst mixture can be passed through a cooling coil where its temperature is lowered to 150° to 250°F. before it reaches the storage hoppers. Another and perhaps more satisfactory technique when shutting down a plant is to cool the catalyst in the regenerator before removal, by blowing with air after the carbon has been burned off completely.

● **Heat balance.** In addition to the ability to transfer large quantities of solids from one zone to another the fluid technique is of particular interest for its ability to transfer coincidentally large quantities of heat. In many fluid catalyst cracking units a transfer of over 150 *MM B.t.u. per hr.* from the regenerator to the reactor is regularly carried out. By this means the heat of regeneration is dissipated and at the same time used to supply the heat required for preheating, vaporizing, and cracking the oil. This is accomplished by direct contact of oil with hot regenerated catalyst, which provides a very satisfactory means for heating hydrocarbons and eliminating expensive heat exchange surface. Thus, feed stocks that are difficult or impossible to vaporize in conventional tubular equipment may be charged directly to a fluid cracking reactor without interruption for long periods of time.

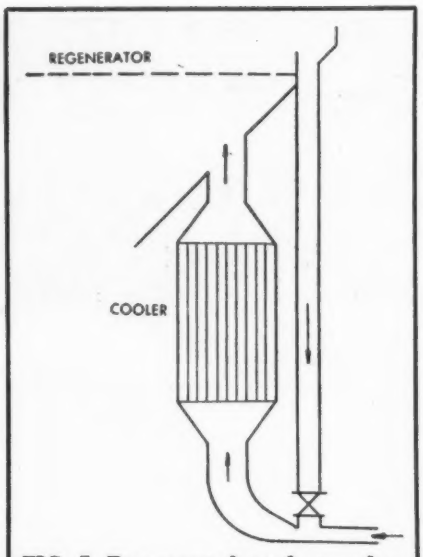

FIG. 5. Regenerated catalyst cooler.

The principal variables involved in an overall heat balance around the reactor and regenerator of a fluid cracking plant are shown in Fig. 3. This plot shows the relation between the amount of carbon or other fuel burned in the regenerator and the reactor temperature obtainable at several feed preheat temperatures. If the rate of carbon production from the cracking step is less than that indicated as necessary by the curves, the deficiency may be made up by adding oil fuel to the regeneration system. In general practice the use of extraneous fuel is not required for heat balance since more war products can be made by using the entire regeneration system capacity for burning catalytic carbon. In those plants not equipped with furnaces for preheat, feed temperatures between 100 and 400°F. may be obtained and any combination of cracking temperature and carbon burning rate lying in the area between the 100° and 400°F. lines is possible in so far as overall heat balance is concerned. For example, 900°F. cracking temperature may be maintained with carbon burning rates varying between 5.9 and 7.7 per cent on feed.

In all probability, peace-time operation will demand a less severe degree of gas oil conversion and the per cent of catalytic carbon on feed will be lower

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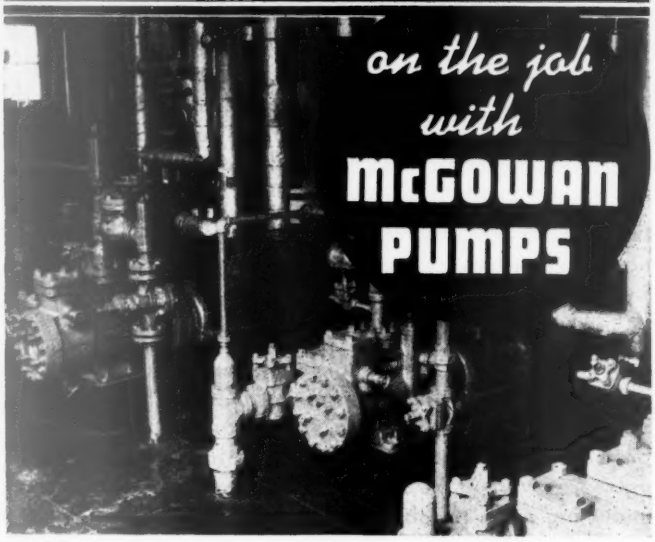

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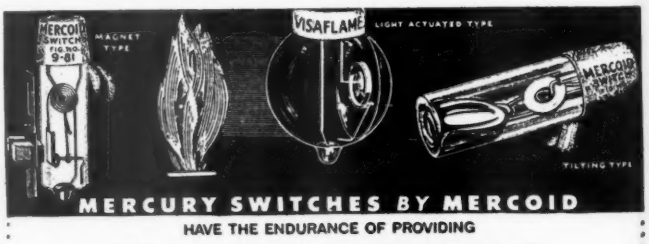

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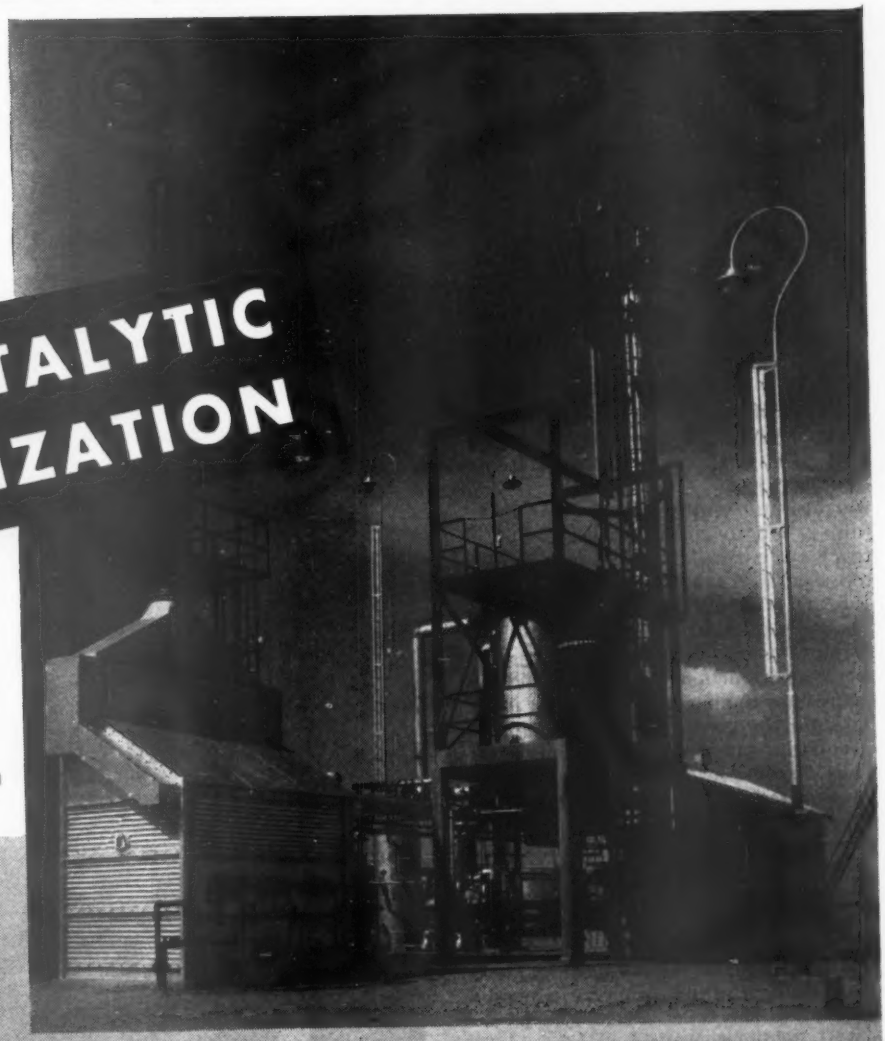

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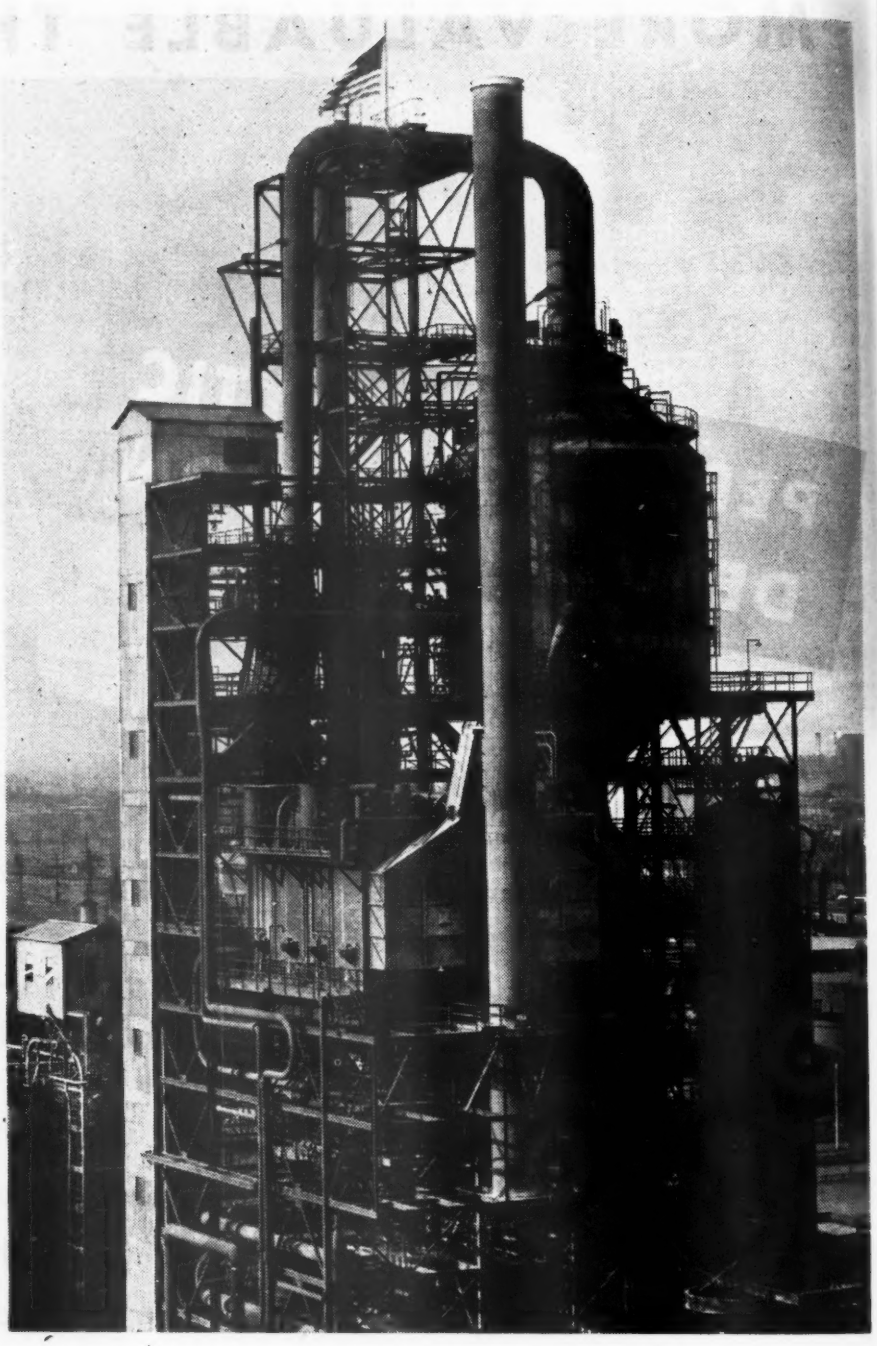
than is present practice. The deficiency in carbon production may be supplied either by the use of extraneous fuel in the regenerator or by supplying the extra heat as additional preheat in the feed. Since there are limitations in the regeneration system such as air blower capacity, etc., greater plant processing capacity may be obtained by the addition of a preheat furnace. If, for example, the furnace is sufficient for maintaining a 700°F. oil preheat temperature, the flexibility as regards overall heat balance will include the entire area between the 100 and 700°F. lines.

Since the heat produced in the regenerator is consumed in the reactor, a heat balance drawn about either of these elements will serve to indicate the magnitude of heat and mass transfer required to satisfy the conditions assumed. In Fig. 4 the relation between catalyst circulation rate expressed as catalyst to oil weight ratio and regenerator temperature is shown for the case of 950°F. reactor temperature. A family of lines representing carbon burning rates of 3, 4, 5, and 6 per cent on feed is presented. These lines indicate that catalyst circulation rates may be increased sharply as the regenerator temperature approaches the reactor temperature. This fact is the basis for the great flexibility in catalyst circulation rate in fluid cracking units. Thus, the line for the 5 per cent carbon burning rate covers a range of catalyst to oil ratio from 8 to 35, or over fourfold when the regenerator temperature is varied from 1150 to 1000°F. This variation is possible without altering other primary processing conditions.

It has been pointed out previously that additional heat to satisfy heat balance may be added in the form of extraneous fuel. Conversely, excess heat may be removed by incorporating a regenerated catalyst cooler as is shown in the design of Fig. 5. By this means a part of the heat of regeneration is transferred to boiling water and catalyst circulation may be reduced correspondingly. Thus, catalyst to oil ratios may be reduced to any desired value below those shown in Fig. 4. However, a corresponding amount of furnace capacity may have to be added to satisfy the overall heat balance conditions set forth in Fig. 3.

The extreme flexibility in catalyst to oil ratio, in addition to the possible variations in reactor holdup already mentioned affords a large change in the severity of cracking. Since the degree of conversion may be increased by increasing catalyst to oil ratio or reactor holdup, coincident use of both of these variables may be made in order to attain the best suited cracking conditions for any particular type of operation on stocks of widely differing characteristics.

● **Specific design features.** *Instrumentation.* The instrumentation in a fluid plant is unique in that it involves the measurement and control of pressures, flows, and levels in lines and vessels containing dust. Fig. 6 shows the piping required for a pressure tap for actuation of such instrumentation. It consists of a connection to the point of measurement, into which a small quantity of gas is bled continuously to prevent plugging with catalyst, and a line to the pressure gage or other instrument. A line for cleaning out the tap by a blast of high pressure gas is also indicated. Catalyst holdup is measured by two such taps installed at the top and bottom of the vessel. From the pressure differential thus measured the weight of catalyst between taps can be calculated. To measure the density in the bed, two or more taps must be located in the dense bed and by such an arrangement the catalyst level can be located.



Regeneration vessel of fluid catalyst plant is on upper structure. Below it to the left is the precipitator.

Catalyst flow rate can be measured by heat balance around one of the vessels or by a carbon balance, the latter method involving calculation of the rate of carbon burning from the air quantity and flue gas analysis in addition to a carbon analysis of both spent and regenerated catalyst. For instantaneous indication of flow rate, the catalyst and gas stream can be passed through an orifice or venturi meter, the readings on which are a function of the catalyst concentration of the gas stream. For moderate pressure drops the simplified venturi meter equation has been found to apply to cases where gas-powder mixtures are being metered if the fluid density used is that of the flowing stream. Another more qualitative method has been devised wherein the air rate to the spent catalyst injector and the pressure differential across a measured vertical length of the spent catalyst return line are used. This pressure gradient has been found to depend on the cat-

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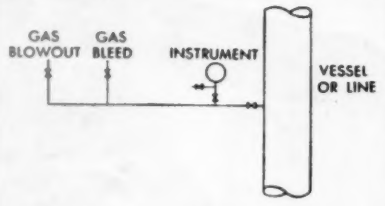


FIG. 6. Pressure connection.

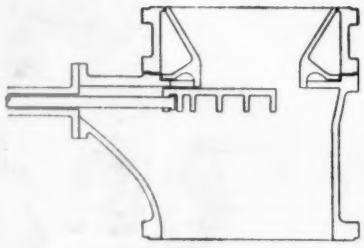


FIG. 7. Slide valve for catalyst control.

alyst circulation rate, other factors remaining unchanged, and the device is a very useful indicator of catalyst flow changes.

Slide valves. Fig. 7 is a sketch of the slide valve used for control of catalyst flow. These valves are simple and rugged and have been found to give little trouble. The plant has a common circulating oil system for motivating these valves through piston operators. The valve is designed to have a large open space underneath so that catalyst accumulations cannot build up and prevent movement of the slide. In 2½ years of operation no case of plugging or binding of the valves is known to have occurred.

Catalyst recovery. Some of the plants are equipped with "multiclone" type cyclones licensed by the Western Precipitation Corporation. These consist of an assembly of small cyclones operating in parallel and mounted in the upper heads of the reactor and regenerator. The collected dust falls into a common hopper located below the multiclones and is returned to the dense catalyst bed through the dip pipes, as already discussed. Cyclones manufactured by the Buell Engineering Company are also in use.

The Cottrell precipitator is arranged for horizontal flow of the gases and the collected dust falls into hoppers below the Cottrell proper. The Cottrell should be operated at 400°F. or lower for best results, compared with the optimum flue gas outlet temperature from the waste gas coolers of 600°F. A system of superheated water spray injectors in the Cottrell inlet line is employed to get down to the desired temperature and at the same time avoid wet catalyst accumulation. Water vapor in the gases to the precipitators is maintained at 20 to 25 per cent by volume to help prevent arcing. During the early operation of the 15,000 bbl. per day units it was learned that the addition of 6 to 10 lb. per hr. of ammonia vapors or about 0.005 per cent by weight of the flue gas caused an additional marked increase in efficiency. This striking result is believed to be due to an increase in electrical conductivity of the solid material, permitting release of its charge to the collection plate more readily.

● **Plant performance.** There are in operation in the U. S. 36 fluid cracking units having a total nominal throughput of about 400,000 bbl. per day. Of these, all but four are of the new downflow design. All these plants are operating to produce aviation base stock and olefins for production of aviation blending agents or butadiene. The 15,000 bbl. per day capacity for the plant referred to in this article represents a nominal design figure. A number of these plants operated by affiliates of the Standard Oil Company (N. J.) have exceeded this capacity by a considerable margin with one unit currently running as high as 25,000 bbl. per day. Runs in excess of 6 months' duration have been made and present scheduled operating periods for units operated by the Standard Oil Company of Louisiana are set up on the basis of 8 months between shutdown periods, indicating that good service factors are obtainable.

Erosion in the downflow plants, in general, has been quite minor. Virtually no erosion has been experienced in lines since velocities have been adjusted with this in mind. In some cases erosion has been noticeable in the cyclone vanes and in the collection tubes adjacent to the vanes. This wear, however, has not been sufficiently serious to affect the operation of the units. A small amount of wear has been found on the gates of the slide valves, which of course are readily replaced during turnaround periods. The minor character of the erosion experience is borne out by the long running periods obtained on the downflow units.

Catalyst recovery is an important item in the operation of the fluid catalyst units since this material is relatively costly. After initial operating conditions were adjusted, very satisfactory catalyst recoveries were obtained on the downflow fluid units. The major catalyst loss is obtained in the flue gases leaving the Cottrell precipitator, the remainder representing the small amount of catalyst in the clarified oil leaving the slurry oil settler.

The following table shows actual catalyst losses obtained in several 15,000 bbl. per day plants operated by affiliates of the Standard Oil Company (N. J.). The figures cover the total measured inventory loss for complete runs, including starting up and shutting down periods.

	Length of run, days	Avg. tons per day loss
Standard Oil Co. of Louisiana—		
No. 2 Unit	181	3.3
No. 3 Unit	180	1.9
Lago Oil & Transport Co., Ltd.	183	3.6

The above figures and other information on current operations indicate a loss of 2 to 3 tons per day on the 15,000 bbl. per day downflow plants. This loss may be appreciably reduced through modification in design.

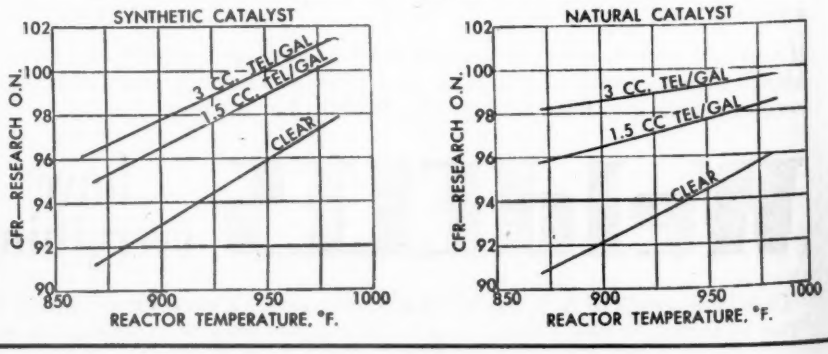
TABLE 1

Yields and qualities of aviation components.

Once-through cracking with synthetic catalyst—commercial downflow fluid plants

	Paraffinic	Naphthenic
Feed stock:		
Gravity, °API	32.0	30.7
ASTM, 50 per cent at °F.	618	539
Diesel index	57.0	46.3
Sulphur, weight per cent	0.34	0.16
Aviation components:		
Base stock (7-lb. r.v.p.), volume per cent	25.8	31.8
Excess C_5, volume per cent	6.6	0.0
Total C_5, volume per cent	11.8	8.9
Total C_4, volume per cent	17.5	15.9
Butylenes, volume per cent	8.7	6.8
Isobutane, volume per cent	7.0	7.2
Cracked gas oil, volume per cent	33.5	35.1
Quality of untreated base:		
Reid vapor pressure, lb. per sq. in.	7.0	7.0
ASTM, per cent at 293° F.	90.0	75.5
Bromine number, eg./G.	65	47

FIG. 8. Anti-knock quality of fluid catalyst motor gasolines from paraffinic gas oil feed stocks. Basis 10 r.v.p., 400°F. end point motor gasoline.



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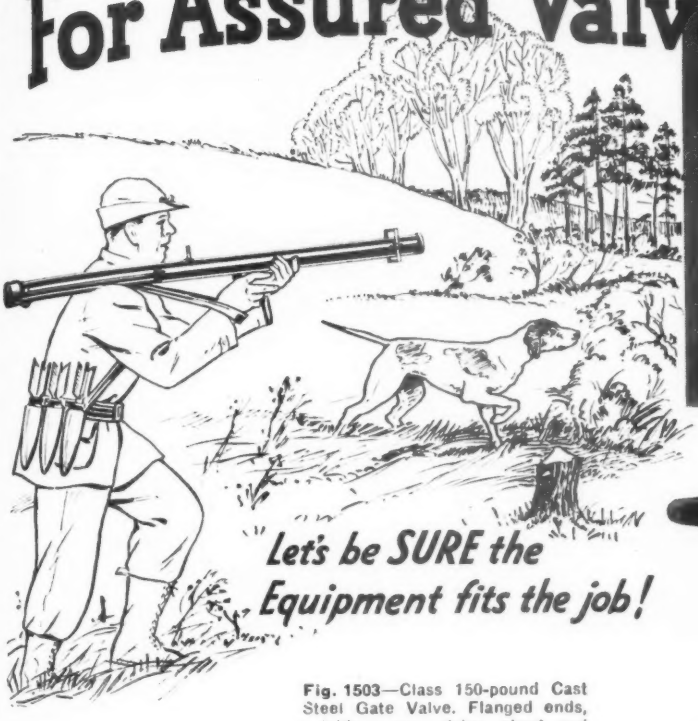

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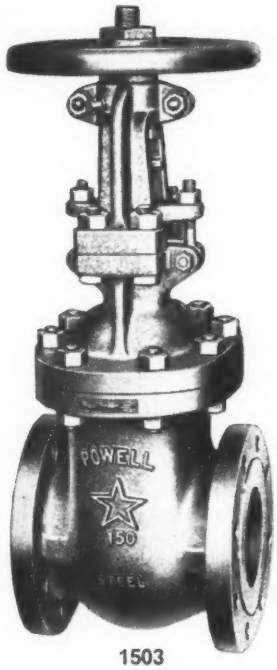
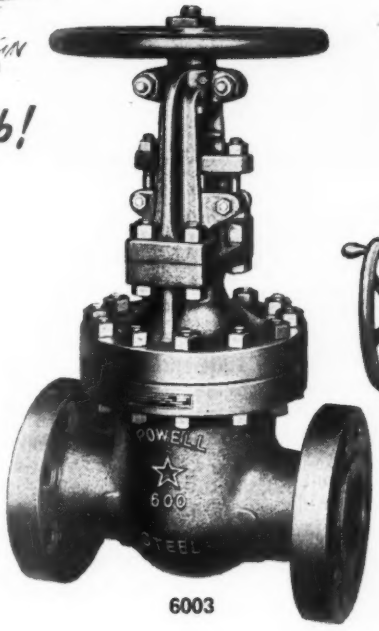


1503

Fig. 1503—Class 150-pound Cast Steel Gate Valve. Flanged ends, outside screw rising stem and bolted flanged yoke.

Fig. 6003—Class 600-pound Cast Steel Gate Valve. Flanged ends, outside screw rising stem and bolted flanged yoke.

Fig. 3023—Class 300-pound Cast Steel Gate Valve, designed and built especially for catalytic cracking plants in the production of 100 octane aviation gasoline. Equipped with steam blanking arrangement and top mounted, enclosed, explosion-proof electric motor operator for quick, positive opening and closing.



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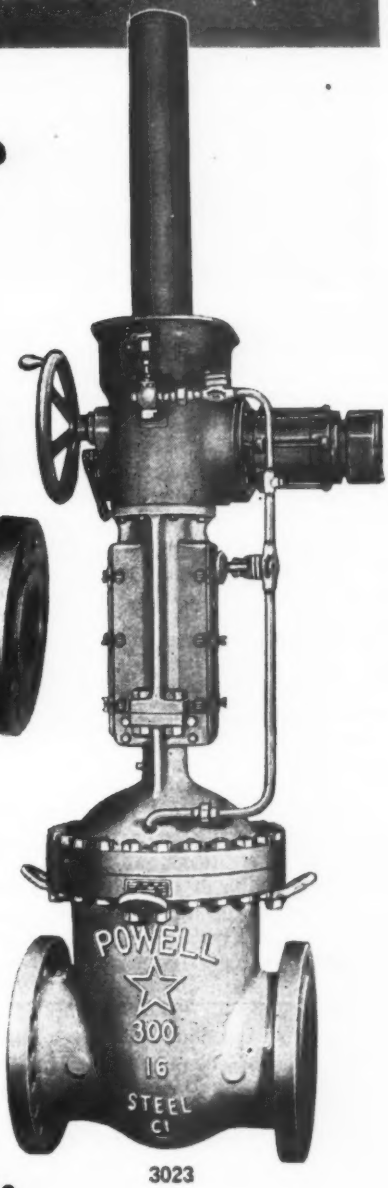

3023

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POWELL VALVES

Control room of fluid cracking plant, cracking section panel on the left and fractionator panel on the right.

● **Process data.** Maximum production of materials of war has been the prime objective in the operation of all fluid catalyst plants. Cracking has accordingly been carried out for the most part at high temperatures with a synthetic type catalyst, charging gas oils once through at fairly severe levels of conversion. Thus, of the five plants of the improved type currently operated by the Affiliates of the Standard Oil Company (N. J.), only the first was operated with a natural type catalyst at the relatively mild conditions which are more representative of normal operations for the production of motor gasoline; this operation established in a short period the satisfactory performance of the new design, and little process data on this type operation are therefore available.

Current specification 100-octane aviation fuels are composed primarily of isopentane, base stocks, and alkylate of which the latter is the most vital component due to its high anti-knock quality. Consequently, in integrated refinery operations for maximum production of 100-octane aviation fuel, the most efficient utilization of fluid catalyst units normally involves cracking for maximum production of butanes, butylenes and amylenes to be used as alkylation feed stocks, with a secondary emphasis on quality of raw aviation base stock, which can be readily improved by further refining in equipment other than catalytic. Typical yields and qualities of aviation components produced from fluid units operating in this manner are presented in Table 1. Owing to wartime restrictions, it has been necessary to omit disclosure of the octane numbers of the aviation gasolines produced. Illustrative of refinery methods employed to improve raw base stock quality are results in Table 2 obtained by simple acid treating raw stocks with spent sulphuric acid from alkylation plants.

TABLE 2

Acid treatment of fluid catalyst aviation base fractions for anti-knock quality improvement.

Paraffinic gas oil feed

Catalytic aviation base fraction	Light naphtha		Heavy naphtha		Calculated blend
	Raw	Treated*	Raw	Treated†	Treated‡
Typical data:					
Gravity, °API	65.9	66.4	36.9	36.4	44.3
R.v.p., lb. per sq. in.	5.0	5.0	2.0	2.0	3.0
Bromine no., cg./G.	87.5	55.1	17.3	3.6	...
Sulphur, weight per cent	0.030	0.020	0.054	0.025	0.024
ASTM distillation:					
I.B.P., °F.	125	125	220	228	...
10 per cent at °F.	142	146	257	263	185
50 per cent at °F.	158	160	288	289	270
90 per cent at °F.	197	193	325	325	318
F.B.P., °F.	236	221	350	348	...

*Treated with 15-lb. of 93 per cent H_2SO_4 per bbl. raw naphtha.
†Treated with 23-lb. of 90 per cent H_2SO_4 per bbl. raw naphtha.
‡Using production proportions.

Information on quality of motor gasoline fractions produced in commercial operations of the downflow fluid catalyst plants is quite limited at the present time. Motor gasolines produced in the commercial upflow units from paraffinic gas oils, however, have ranged in quality from 91-98 *CFR-R* octane number clear, and from 98-101 with 3 cc. *TEL*/vol. added. The anti-knock quality of the product is influenced largely by cracking temperature and type of catalyst, as illustrated in Fig. 8. Of significant importance, also, is the type of feed stock cracked:

Type feed	Paraffinic	Naphthenic
Feed stock:		
Gravity, °API	31.0	25.0
ASTM, 50 per cent at °F.	650	535
Cracking temp., °F.	965	965
Product quality:		
R.v.p., lb. per sq. in.	10.0	10.0
Octane number CFR-R clear	96.8	99.8

Unleaded motor gasoline of essential 100 *CFR-R* octane number quality can be readily produced in commercial operations from current design fluid catalyst plants.

More detailed information on quality of products produced from fluid catalytic cracking operations has been published in previous articles.[1, 2, 3]

● **Other applications.** The fluid catalytic cracking process represents the first application of the fluid technique to a commercial process. This new tool should find wide application in many other industrial catalytic operations, which may or may not involve catalyst reactivation. In addition, fluid technique should be of use in the broad field involving the addition or removal of substantial quantities of heat. Such operations need not be confined to catalytic processes, since inert or reacting solids may be circulated. The ability of the fluid process to maintain uniform temperatures throughout a reaction vessel is highly advantageous for reactions of an exothermic or endothermic character. Other processes in which difficulties are encountered in heating or vaporizing materials in conventional equipment may be able to utilize fluid technique. Operations such as ore reduction, coking of coal, water gas manufacture and other specialized chemical processes regardless of operating pressure may represent interesting applications of the process. Concurrent or countercurrent modifications of fluid technique are possible either by stagewise operation or suitable baffling of the reaction vessels.

Commercial application of the fluid process to catalytic cracking has demonstrated to industry a new chemical engineering technique. Wide interest in the fluid cracking process has already been evident and application to many new processes and industries is visualized.

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★★★

TEXAS OIL MAN VISITS ENGLAND'S NEW OIL FIELD

By **E. J. MUTH**, U. S. Navy

EXCLUSIVE

It was my good fortune and pleasure one afternoon to enjoy a visit in the main offices of the Anglo-Iranian Oil Company in London. During the course of the afternoon I met an official* who had just returned from a trip to the United States, by plane, where he visited friends and associates in Houston, Dallas, Oklahoma City, and Tulsa.

He described the operations of the Anglo-Iranian Oil Company in Iran. My knowledge of their production in Iran, I must admit, was limited and I was amazed to learn that their 14 producing wells flow an amount of crude oil equivalent to the aggregate output of East Texas' 24,000 wells. The methods of drilling, completion, and flowing of these wells without taking any of the free gas from the dome was exceedingly interesting.

The most important phase of our conversation and of considerable interest to me was a reference to results of drilling operations in England since the outbreak of war.

Prior to the outbreak of war the operations of this company in England comprised a small shallow-seepage type of oil field, discovered in 1939, at Formby, in Lancashire, near Liverpool. Subsequently the discovery well of a new oil field was completed at Eakring, in Nottinghamshire, which is about 53 deg. latitude; but due to security necessitated by the war the development of this field and engineering data have not been available for general dissemination without certain reservations.

My enthusiasm was clearly evident when he suggested a trip to the Eakring field as a courtesy of their company and I knew one of my long suppressed desires to visit an oil field again was soon to be realized.

● **250 wells produced nearly 3 million bbl.** The drilling and production operations in England during the war years were described to me by the official at the London office. I learned that 380 wells of varying depth had been drilled, covering the testing of 45 separate structural areas, and of these 250 are producing wells. In the six years this work has been quietly going on, England has established herself as a petroleum-producing country by the production of nearly 3 million barrels of crude oil. The gravity ranged from 19.2 to 40.1 deg. API, but, analyzed in England in the metric system the specific gravity at 60°F. ranged from 0.939 to 0.824.

At Newark, Nottinghamshire, I was met by a representative of the D'Arcy Exploration Company, a subsidiary of the Anglo-Iranian Oil Company, and driven through the producing properties.

A trip to an English oil field, through the Midlands from London, is quite unlike a trip to one of the Mid-Continent oil fields. The English countryside, particularly at this season of the year, is a picturesque pattern of beautiful small farms resembling a patchwork quilt. One would hardly expect to find a field office, warehouse, pipe racks, storage tanks, and pumping wells, all cleverly camouflaged, nestled in the center of rolling green farms and small forests.

The symmetry and beauty of the land in Nottinghamshire is a decided contrast to the bleakness and miles of plains or undulating prairies of Texas where many of our American producing oil fields are situated. I cannot be eloquent enough to describe the locale of this English oil field, I would be required to digress further to give you a visual picture of this area and such would be aside from my present topic.

E. J. MUTH

The author, now with U. S. Naval forces in Germany, has given permission to publish parts of an interesting letter he wrote the Petroleum Engineer's Club of Dallas, Texas, to which he belongs.

Muth was employed by the Buffalo Oil Company, Dallas, before he entered the service. He studied at Tulane University, University of the City of Los Angeles, Southern Methodist University and the Sorbonne. He was first associated with Phillips Petroleum Company.

● **Development completed with light rigs.** The drilling program for the area visited had been completed, consequently I was unable to witness their drilling methods, but was told that they had used unitized drilling rigs with jack-knife portable derricks. At the outbreak of the war heavy-duty steam and diesel powered drilling equipment utilizing 136 ft. and 94 ft. derricks had been used for exploration work down to depths of 8000 ft., but, with the necessity for accelerated development of the 2000 to 2500-ft. proved producing zone to obtain increased production, it was necessary to switch from these heavy units to the lighter and more portable drilling units. The lightweight units were obtained from America and valuable suggestions were obtained from various drilling contractors who had had experience in the Illinois Basin field, where the drilling conditions were comparable to those in Nottinghamshire.

Casual inspection of the field did not reveal a regular pattern of well spacing. The original plan had called for wells being approximately 500 ft. apart, but additional wells were drilled between the first ones giving an overall pattern of one well to 2 or 3 acres. This spacing was considered satisfactory for a reservoir of this type.

● **Four sands yield oil.** The geological characteristics of the Eakring field consists of a simple, domal structure with minor faulting, containing a number of separate, sometimes lenticular, and independent oil sands. The Eakring field has been extended to and includes two other minor producing areas nearby, namely, North Eakring and Duke's Wood to the South. The whole field is approximately two miles long by a half mile wide. Four separate oil sands yield production in the central part of the structure. The flank wells have only two producing sands. All wells are completed in two or more sands and none of the formations is produced separately.

Although the subsurface structure is a domal high, production is obtained only from the center of the highs and is rather spotted. With these various producing levels it is easily understood why adjacent wells may be producing an entirely different type of crude. One well may yield a greenish oil and the offset producer may make a dark brown crude. Each sand has its own particular type of crude oil and edgewater.

The oil horizons lie mainly in the Millstone Grit series of the Upper Carboniferous, but they extend upward into the basal part of the Lower Coal Measures. The porosity ranges from almost 0 to 20 per cent, and the permeability varies from 2 to 1000 millidarcys. The oil column is about 200 ft.

*C. A. P. Southwell.

Because of the irregular reservoir characteristics in this area as well as throughout England, considerable difficulty has been encountered in determining various sub-surface data for development work. A large amount of information has been obtained from the various coal mines throughout this section, correlations have been made with the data obtained from drilling and geophysical surveys. With respect to the geophysical surveys, it has been found that reflection methods have not been so successful as refraction.

● **Wells completed with pumps.** The initial production of the wells has varied from 7 bbl. to 375 bbl., being lifted by pumps. The gas-oil ratios are very low. They are reported to range from 10 to 20 volumes of gas to 1 volume of oil. Translated into American terminology this range is from 56 to 112 cu. ft. per bbl. and indicates that the crude is undersaturated with gas.

The production decline for the field was rapid until the reservoir pressure reached the saturation pressure of the crude. The decline has been small since then. The wells of large initial production have followed the usual decline curve of gas drive production, but the small, low-permeability wells have exhibited a small, regular decline. Although the gas-oil ratio is small, the gas collected from the water-oil separators and the annulus between the casing and tubing amounts to approximately 175,000 cu. ft. per day.

The gas from the field flows through a small and compact charcoal adsorption plant designed for the recovery of benzole from coal gas. About 1 gal. of gasoline is recovered per M cu. ft. of gas processed. This consists of pentane and heavier fractions. The three-stage charcoal adsorption plant is electrically operated and fully automatic. It was an interesting unit and ideal for small operations. The stripped gas from this plant is used in the boilers on the property as fuel.

The oil has nearly twice the amount of paraffin wax that is found in the average Mid-Continent crude, but is low in sulphur content. The waxy nature of the crude has resulted in additional problems.

● **Methods of combating paraffiin.** Surface lines are "go-deviled" regularly to remove the wax. The greatest problem with the wax in the wells has been in the top 800 ft. as the wax begins to settle out at a temperature of 80°F. and below. To counteract this condition the tubing has been insulated with wooden insulators down to about 1000 ft. and contact made with the casing at this level. At the surface the tubing is supported by a plastic insulator.

Low voltage current from a direct-current generator built on a truck bed is connected to the tubing and heats the tubing down to the 1000 ft. contact point to a temperature of about 110°F. This much heat melts the wax and permits the well to pump.

● **Water production problems.** Steam coils in the oil-water separators at each tank battery are used to heat the separators to 110°F. A small amount of sulphonated oil is added to the production stream as an emulsion breaker and the mixture passes through wood-wool packing. This reduces the water content of wet oil to about 1 per cent. At the present time the water production has increased to about 60 per cent of the total production.

The tank batteries are composed of two 100-ton tanks, approximately 700 U.S. bbl., and a separator connected by 2-in. lines to about 40 wells. A boiler plant is built at each battery for heating the separator coils. The fuel for the boiler comes from the stripped gas of the adsorption plant.

At present some of the wells are producing larger quantities of water than others. The plans now are to separate the wells. Those that produce only a little water will be connected to one battery, and the wells that produce considerable water will be connected to another battery. Several of the boiler plants can be eliminated in this way as it will not be necessary to heat all the separators in order to remove the paraffin wax and water.

Crude oil is produced from the relatively shallow sands of the North Eakring and Duke's Wood oil field of England by small pumping units carefully guarded as shown above.

The central pipe yard and machine shop, still wearing a bit of wartime camouflage, is shown below.

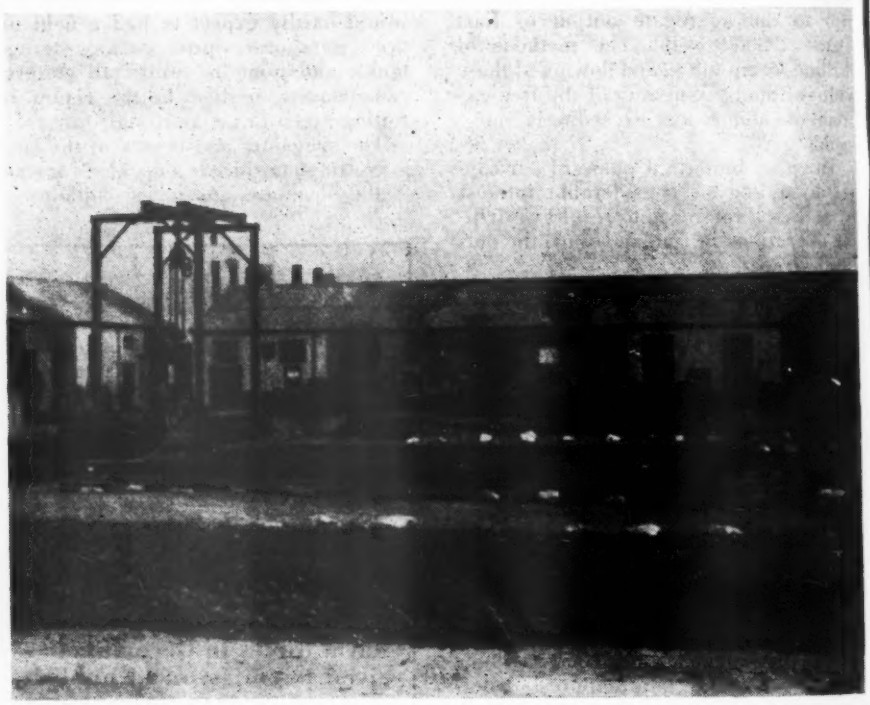

Illustration at left shows tool in setting position, J-tool released, slips expanded, and collar finder contacting casing. Right view shows front of tool, with J-tool, friction springs, slips, and other mechanical features.

1. Is set, anchored and locked at any depth, at any time, in flush joint, welded, or threaded and coupled casing.

2. Safety setting tool prevents loss of whipstock in the hole.

3. If whipstock hits obstruction while being run, the setting tool safety shear pin shears and signals operator, through weight indicator. Operator then has 10 feet of downward movement to prevent loss of tool in hole.

4. Collar finder remains in retracted and protected position until time to set whipstock. A quarter-turn releases J-tool, and collar finder contacts inside of casing.

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● **Slush pits treated with gypsum.** The well sites are as small as practicable without being cramped. Elevations of the wells are about 300 ft. and the total depths are about 1900 ft. subsea. The slush pits have been well covered. When drilling was completed the derrick was removed, the mud-pits were treated with powdered gypsum to coagulate the mud, preventing the usual impervious state of the soil and thereby assisting the normal soil drainage. The pits were covered and at frequent intervals treated with chemical agents to restore the natural nitrates to the soil for resumption of farming. Each well has been fenced to prevent cattle from getting close to the pumping equipment.

● **Pumps operated by electricity.** The pumping equipment is all electrically powered, as is most of the equipment on the property. Electrical power was also available during the actual drilling operations to operate the 150-hp. flameproof slip-ring drilling motors, but on completion of drilling the current was stepped down for the small individual motors, ranging from 2 hp. to 15 hp., used for operating the pumping units. Various types of pumping units have been installed. Some were imported from America and others were manufactured in England.

The wells are equipped with 2-in. sectional liner tubing pumps. A few 2½-in. pumps were originally installed in some of the larger wells. Most pumps are 5 ft. by 2 in. by 1¾ in. These are run on 2-in. plain tubing and operated by ⅝-in. sucker rods. So far there has been little trouble with the pumps or the need to change rods.

It was especially interesting to note the extent to which electricity has been used throughout on the property. From the beginning of drilling operations to the present stage of production electricity was used almost entirely. As a result there have been few occasions for shutdowns. The original investment for electrically-powered equipment has in some instances been higher than for other types of equipment, but the ultimate cost of operation is believed to represent a savings in this particular area.

● **Rock bits needed for drilling.** Various American types of rockbits were used in drilling the wells. An average of 100 ft. per rockbit was recorded when using a chemically treated mud made of ground shale. By experiment it was found that beginning wells with clear water and adding a little bentonitic material offered an excellent circulation fluid. As much as 800 ft. was drilled with one bit and this mud. To conserve on drilling bits before they were worn bald, they were treated by a process evolved by an Austrian inventor. Tungsten carbide in a tubular rod form was welded on the worn teeth with an oxy-acetylene flame. The plastic deposit was shaped with a steel file. It was found that this added as much of 75 per cent to the life of the bits. The process was necessary inasmuch as the bits were virtually impossible to obtain from America.

● **Installations camouflaged.** The office buildings, warehouses, and machine shops resembled our own in many respects except for the camouflaging on the buildings. The machine and repair shops were equipped to service all motors, pumps, and other items normally required in an oil field. The repair shop has been able to duplicate much of the equipment on which patent rights had elapsed or run out. When there was an immediate need for production or drilling equipment similar to that which had been obtained from America but was not available at the time, the machine and repair shops have duplicated this equipment with certain modifications to suit their requirements.

● **Government owns mineral rights.** With but a few exceptions the methods for drilling, running pipe, cementing, and completing have been conventional and their present system of operation is equivalent to our own with a few exceptions.

There is one main difference in oil production that I might add, and that is in respect to mineral rights. All oil mineral rights are owned by the Government. The land owner does not derive any royalty interest from the oil produced, but is compensated for damages to his farm or the added improvement of roads the company has had to build. A royalty payment of a stipulated amount per bbl. is paid to the Government, and, in some respects, this is comparable to our state and federal taxes.

The measurement of oil for the payment of the royalty fee to the Government is made at the storage tanks at the railroad siding some miles from the field. The oil is shipped by train from the railroad siding storage tanks to refineries several hundred miles away.

● **Production aided by shooting.** Various methods, shooting, acidizing, and water rocking with wetting agents have been tried to increase the production. Shooting has proved the most favorable. In multiple sands, the shooting has caused caving and necessitated the use of an asbestos-cement liner, which is drilled up after shooting.

The Anglo-Iranian Oil Company is continuing the search for oil in England and is employing various methods to determine subsurface conditions. Core tests are being made by portable drilling units and geophysical surveys are being conducted.

The sight of wells with familiar trade names on much of the equipment and well service crews at work was a pleasant interlude for me when I visited this field. It has been a reminder of the work I look forward to becoming active in again.

For many of you, I know that a visit to an oil field of this nature would be highly interesting. I hope that I have given you some conception of the conditions that exist and how production is being handled. It would have been possible for me to have gone into greater detail, but it was not my intention to make this letter a technical report.

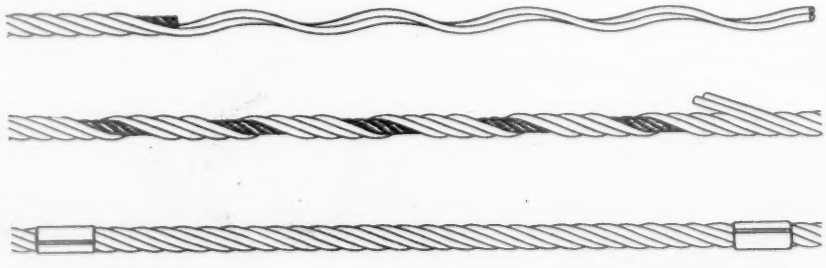
★★★

P 094.13

REREEVING A NEW WIRE ROPE

When replacing an old and worn rope with a new one, on any machine that requires pulling the new rope through blocks, over sheaves and on to drums, here is an idea that will save not only time and temper but money and profanity.

From the end of the old rope, unlay and remove four of the six strands to a distance of about 2 or 3 ft. Similarly remove two of the six strands from the new rope to be installed.



Splice, or more properly speaking "lay" the two together and tape the ends to prevent unraveling. This will permit the new cable to be pulled through blocks and pulleys and reeved rapidly, accurately and easily.

This, of course, can be done only with preformed wire rope, for it is only that type of wire rope with strands that will lie inert. To remove the seizing wires and attempt this procedure with non-preformed wire rope would be courting disaster, for ordinary wire rope, so cut, would virtually explode. ★★★

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New Compound-308 Inserts operate efficiently for three to five times as long as regular inserts in ordinary mud. In hot mud, treated mud or oil and gas, these new inserts last up to **ten times longer** than ordinary oil-resisting inserts. This gives you lower valve costs and greater freedom from slush pump troubles.

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ZINC ANODES FOR PREVENTING CORROSION OF DISTRIBUTION MAINS*

By **C. L. MORGAN**
Division Engineer, United Gas Corporation

THE purpose of this paper is to relate experiences with the use of zinc anodes to prevent corrosion to certain steel gas distribution mains. It is not the intention of the writer to delve into the theory of cathodic protection; however, an attempt will be made to relate from the gas distribution system operator's point of view the need for cathodic protection on steel gas distribution mains, the method employed in application of cathodic protection to mains, and the results obtained. The practical operator, although interested in the theory of cathodic protection, is more concerned with what it will do and how much it will cost.

The United Gas Corporation in 1930 acquired a number of gas distribution systems situated in the Gulf South section of Texas and Louisiana. Steel mains in these systems are of sizes from 2 to 20 in., and most of them were installed between 1925 and 1930. Practically all steel mains were treated with a protective covering consisting of a pipe line paint primer and one application of hot asphalt. The main pipe was then wrapped with 15-lb. asbestos felt and rolled in sawdust. Although some care was given to the proper application of the covering to lengths of pipe in treating yards or over the trench, the pipe usually received rough treatment before it reached the bottom of the trench. Welds, fittings, and service connections were not always treated. No attempt was made to prevent galvanic corrosion caused by action of dissimilar metals, and the mains were not insulated from other metallic structures.

These distribution systems when acquired, therefore, consisted of steel mains poorly coated as compared with present day standards, having numerous spots and bare fittings, including galvanized fittings, and metallically connected with other underground structures in the immediate vicinity. These gas distribution systems were always connected to the local water system by accidental contacts between the two structures or by connections through hot water heaters.

The soil in which these systems are located is corrosive, and shortly after the systems were acquired, failures in the mains began to occur. These failures become more frequent with increased age.

Failures in the mains continued to develop, resulting in numerous dangerous gas leaks, and it was necessary for some of the mains to be repaired, reconditioned, or replaced as circumstances and conditions dictated. This work was expensive, especially in sections where it was necessary to remove permanent reinforced concrete pavement. The value of gas lost, in most instances, was very small in comparison with the cost of making repairs; however, the hazardous condition created by the existence of leaks required that the leaks be eliminated as promptly as possible after detection, regardless of the cost. This repair work was irritating and annoying to the public, especially in thickly inhabited areas and when it was necessary to work during the night.

In 1933 the pipe line division of the company began the use of cathodic protection, using rectifiers, to prevent corrosion to cross-country pipe lines. The results were very encouraging. Serious consideration, however, was not given to the application of this form of protection to distribution mains at that time. A rather feeble attempt was made to arrest corrosion on several isolated sections of one of the larger distribution systems with cathodic protection by the use of small rectifier units, but the results were far from satisfactory, mainly because of the incompleteness of installations and lack of proper attention to their operation.

IN 1941 corrosion leaks were occurring so frequently on steel welded mains in the business section of Houston that serious consideration was given to replacing the mains in that section of the city. These mains consist principally of 6-in. and 10-in. pipe, totaling 24,000 ft.; service lines were not included in this total. It was estimated that it would cost $102,480 to replace these mains. There were 24 corrosion leaks detected and repaired on the mains during the year of 1941; the cost of finding and repairing these 24 leaks was $2500. The curve in Fig. 1 indicates the leaks that were found and repaired on these lines since 1931.

Experiments were conducted in Houston to determine current requirements for cathodic protection of mains similar to those in the business section. These experiments indicated that mains with coatings comparable to coatings on mains in the business section and located in similar soils responded readily to cathodic protection and that current requirements for protection were surprisingly low if mains were insulated from all other metallic structures. Results of the experiments were so encouraging that in the fall of 1942, it was decided to attempt to protect welded steel lines in the business section of Houston and in other "hot spots" in the system by cathodic protection, using zinc anodes as a current source.

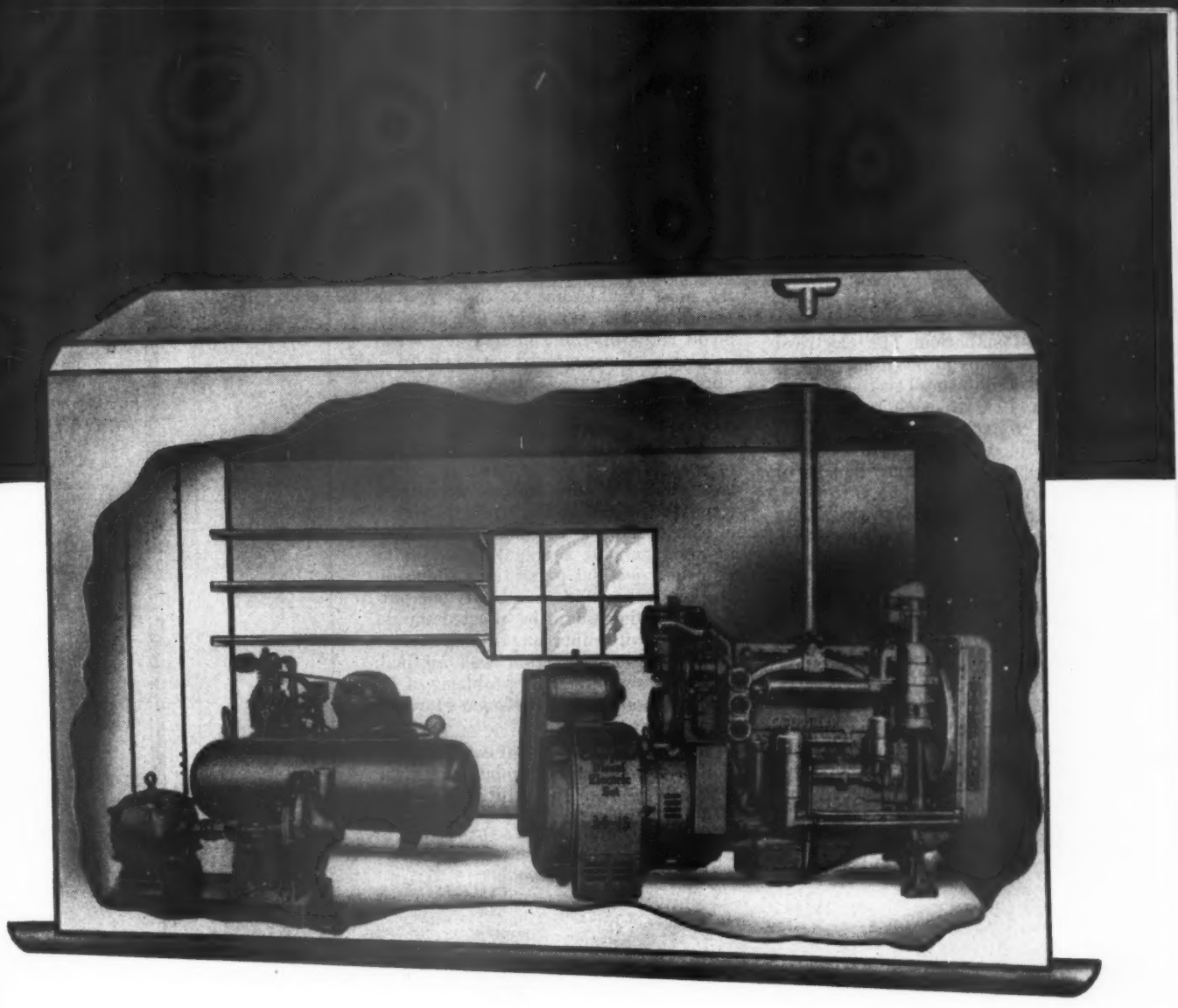
The decision to use zinc as a source of current was reached after considerable experiment, investigation, and deliberation. It was believed that zinc anodes properly placed and distributed could be used satisfactorily to protect coated mains, and by using zinc the concentration of excessive current at any one location could be avoided.

Although zinc had been used as a current source for protecting a few long transmission lines, there was very little information available on the performance of zinc over a period of years. The meager information available indicated that although in some locations the zinc remained active for years, in other locations it became passive in a year or two and failed to deliver appreciable current to the lines. It seems that the environment or type of soil in which the zinc was located was an important factor in the performance of the zinc. The purity of the zinc seemed to be especially important in preventing local action on the anode.

In the absence of sufficient information regarding the performance of zinc in different environments and under different conditions over a long period, a number of short period tests were conducted to obtain information on the performance of zinc in Houston. The results of these tests were used as a guide in the first installation of zinc. A larger number of tests were set up to be run over a period of several years to obtain more detailed and conclusive data on performance of zinc over longer periods.

Selection of the purity, size, and shape of anode was of great importance. A 99.9 per cent pure zinc plate having dimensions of ½ in. by 3 in. by 36 in. and weighing 14 lb. was finally selected. The principal impurities were 0.08 per cent lead, 0.008 per cent iron, and 0.004 per cent cadmium. These anodes could be obtained and delivered in Houston for $1.66 each. To prevent possible segregation of the anode in the event corro-

*This paper was prepared for presentation at the American Gas Association Distribution Conference. That meeting was not held, however, because of war restrictions. It is scheduled for publication in the October issue of the *AGA Monthly*.



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sion was not uniform, one edge of the anode was covered with pipe line primer and enamel. The cost of handling, putting on the enamel strip, and drilling and soldering on pigtail connections added $0.49 to the cost of anode, making a total cost of $2.15 for the anode ready for installation. A detailed drawing of the anode is shown on Fig. 2.

THE preparation of mains to receive protection is probably the most expensive part of the installation. The electrical continuity of mains to be protected was usually broken into small sections of approximately 1000 ft. each to facilitate clearing of contacts between mains and other metallic structures. In most cases this was done by insulating flanges of existing valves with the line in service. The gasket material between valve flange and companion flange usually provides satisfactory insulation between the flanges. The bolts were insulated from flanges by removing them one at a time and enclosing them in non-metallic tubes and using non-metallic washers under steel washers. This method of insulation was very satisfactory and inexpensive. In a few cases it was necessary to install special insulating fittings in the mains.

Frequently it was desirable to operate several sections together, and in those cases bonds were installed across insulated fittings. Service connections were usually insulated at the meter, thereby providing protection for the service line. Intentional contacts, consisting principally of bond wires to other structures originally installed during existence of the electric street railway system as a cooperative drainage program, were found and cleared. Accidental contacts were the most troublesome, as there was no record of their existence. The use of a 6-volt motor-operated interrupter buzzer and pipe locator proved very helpful in finding these contacts. In a few cases it was necessary to supplement the pipe locator test with a voltage drop survey on the main to locate contacts. It was necessary, of course, to clear mains of all contacts before the amount of current required for protection could be determined. In addition to making it easier to find contacts, segregating of mains into short sections permitted a wide separation of the anodes, and only one particular section would be affected should a contact with other metallic structures develop after protection was applied. This also simplified the problems of locating contacts that developed after the mains were protected.

Realizing that the use of cathodic protection on mains would probably be more generally used in the future, standards

FIG. 2.

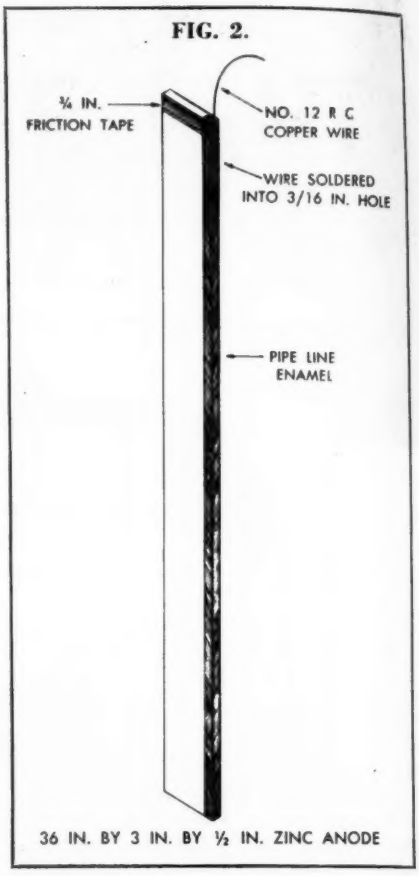


FIG. 1. Note: Cumulative corrosion leaks on the steel mains in the business section of Houston. Mains installed in 1927-1930. Cathodic protection completed first part of 1944.

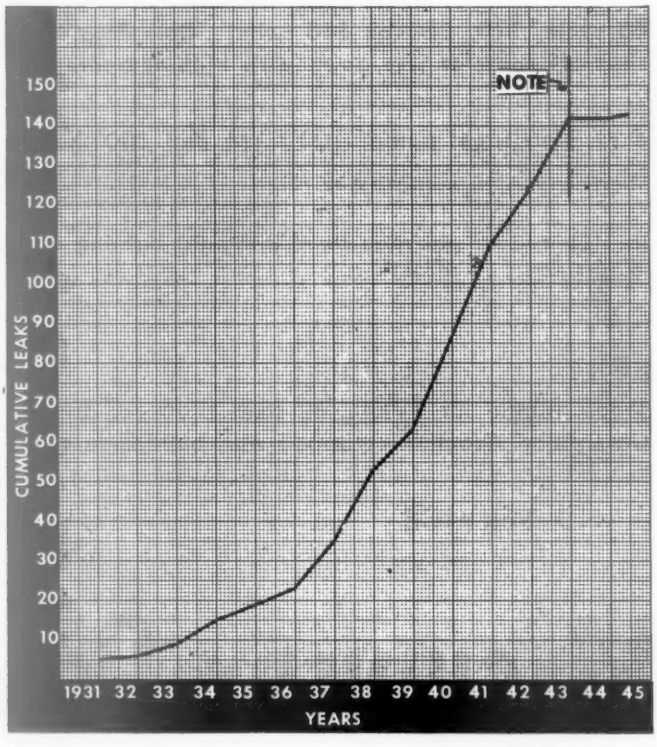
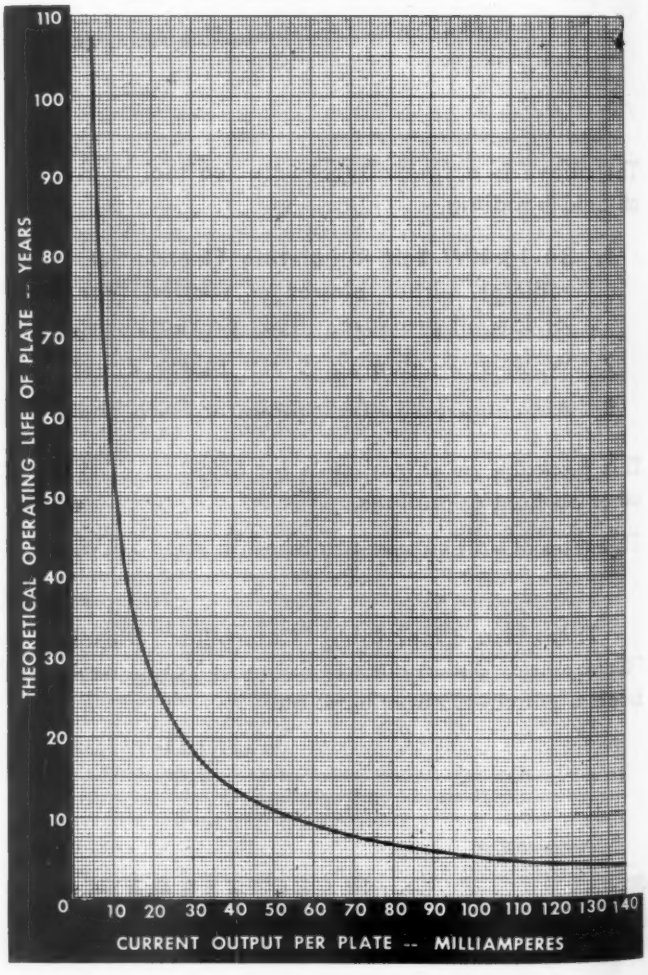


FIG. 3. Theoretical operating life of a 14-lb. zinc plate at 90 per cent current efficiency.



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for new constructions were revised so that protection could more readily be applied later. These changes in new construction standards were also designed to prevent galvanic corrosion caused by connecting dissimilar metals under certain conditions. The most important changes to these construction standards required insulating all service lines at the meter, insulating all steel pipe from cast-iron pipe, bonding across all open couplings in steel mains and in steel service pipes that are connected to steel mains, and discontinuing the use of dissimilar metals under certain conditions.

There is no doubt that insulating the service line from the house piping is important in the prevention of galvanic corrosion to steel service lines. Numerous cases of service line failure have been found where poorly coated steel service pipe was connected to underground copper water pipe. The gas service line and water systems are usually connected through the water heater. Use of copper pipe by water companies and others was very common before the war, and its general use will probably be resumed after the war.

After a section of main to be protected was completely insulated from all metallic structures, tests were run to determine the current required to protect the section. A 6-volt storage-type battery was used as a source of current for these tests, and results of the tests were used as an indication of zinc requirements.

The theoretical weight loss of zinc per ampere of current produced per year is 23.5 lb. at a 100 per cent efficiency. It was decided to design the zinc installations for approximately 15-year life and although definite data on current efficiency of zinc were not available, it was thought that if they were operated at about 25 or 30 milliamperes per plate, approximately 15 years' service from the plate would be obtained. Fig. 3 indicates the theoretical life of a 14-lb. zinc plate operating at different current outputs at 90 per cent efficiency. Later tests indicated that efficiencies of 90 per cent were actually obtained on zinc installations in Houston.

As previously stated, coatings on mains were poor as compared with present day standards; however, the mains responded remarkably well to current. The average current requirements to change the voltage potential between the main and earth from 0.60 volts to 0.85 volts, using a Cu SO_4 electrode to earth, was 0.21 milliampere per square foot of pipe surface when the pipe was completely insulated from all other structures, the zinc to soil potential being 1.10 volts. Approximately 15 plates operating at 25 milliamperes per plate were required to maintain 1000 ft. of well-insulated 6⅝-in. O.D. steel treated pipe at 0.85 volts with reference to Cu SO_4 electrode after the pipe had polarized. As the cost of the zinc and the cost of installing it was such a small part of the total cost of providing the protection, considerably more zinc than required was generally installed. This was justifiable because of lack of data regarding the action of zinc for a period of years.

The short period tests conducted on the performance of zinc indicated that zinc current output was not the same in different environments. A number of different backfill mixtures were used to test the performance of zinc, and a uniform mixture of native clay and powdered dehydrated gypsum (moulding plaster) seemed most promising. This mixture was made with 2 gal. of gypsum to 8 gal. of clay mud, thoroughly mixed by using a mechanical mixer and with sufficient water to form a mixture that could easily be poured. The resistivity of the mixture ranges from 200 to 400 ohm per cm. Table 1 shows a comparison of zinc anodes with several different backfills. It will be observed that when the backfill contained lime or ammonium chloride, the current output was greatly reduced.

The natural soil in many sections of Houston is a stiff heavy clay that shrinks and cracks when moisture is removed.

FIG. 4. Comparison of soil resistivity at same location at rainy season and at dry season using the four-electrode method.

Although the average annual rainfall is approximately 48 in., there frequently are periods of several weeks' duration when no rain falls. It is during these dry periods that the soil dries out and cracks open to a depth of several feet below the surface, although observation shows that soil under concrete pavement remains fairly moist throughout the year. The resistivity of soil near the surface increases as the moisture content decreases. An indication of this is shown by the curve of Fig. 4. The resistivity of soil between 5-ft. and 20-ft. depths is fairly low, being between 500 and 1000 ohm per cm., and the drying out does not usually extend to a depth in excess of 5 ft., except in unusually dry periods.

Several methods of burying zinc were tried. The method that seemed most satisfactory in Houston and most commonly used was to locate points along the main having the lowest soil restivitity to a depth of 20 ft. A 4-in. hole was augered to a depth of 20 ft., and five 36-in. zinc plates were installed in a vertical stack. Each plate was placed perpendicular to one immediately below it, and all plates were connected in parallel with a terminal connector in a box provided at the surface. The hole was filled with gypsum-clay mixture to within 2 ft. of the surface, and natural soil was used in backfilling the last 2 ft. of the hole. Three feet of the backfill mixture was left above the top plate to allow for shrinkage of the mixture. A drawing illustrating this method of installation is shown in Fig. 5. Several of these stacks spaced about 10 ft. apart were sometimes installed at one location. The holes were drilled with hand augers, and selected parts of the drillings were used for backfill mixture. Drilling holes with a hand auger, although satisfactory when only a few holes are required, is slow and hard work, and mechanical equipment will probably be used in the future.

This method of installing zinc plates placed them in fairly low resistant soil with the top plate deep enough so as not to be affected materially by seasonal drying out of the soil. A relatively uniform division of current among plates in the stack is usually obtained as indicated by data in Table 2. The last 5 ft. were difficult to drill with a hand auger; however, it was more economical to get as many plates as possible in one stack in order to avoid disturbing any more permanent pavement than necessary. Very often, stacks of zinc were installed in unpaved parkways. In some cases the stacks were located at points where it was necessary to cut the pavement for other purposes such as clearing contacts. The holes were not drilled deeper than 20 ft., because of a stratum of high resistivity sandy soil is usually encountered below that depth. The stacks were always located some distance from other structures. Fig. 6 shows a plan of a typical installation in the downtown section of Houston.

The lead wire connecting the main to zinc plate at the terminal connection box was soldered to the main. All wire joints were soldered and covered with

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rubber and friction tape; and all bare valve bodies, pipe fittings, etc., were carefully coated with bituminous material. Precautions were taken to reduce as much as possible the current requirement for protection. A standard wire-size arrangement was adopted to identify leads in the curb box to avoid the necessity of using tags. This arrangement is illustrated in Fig. 5.

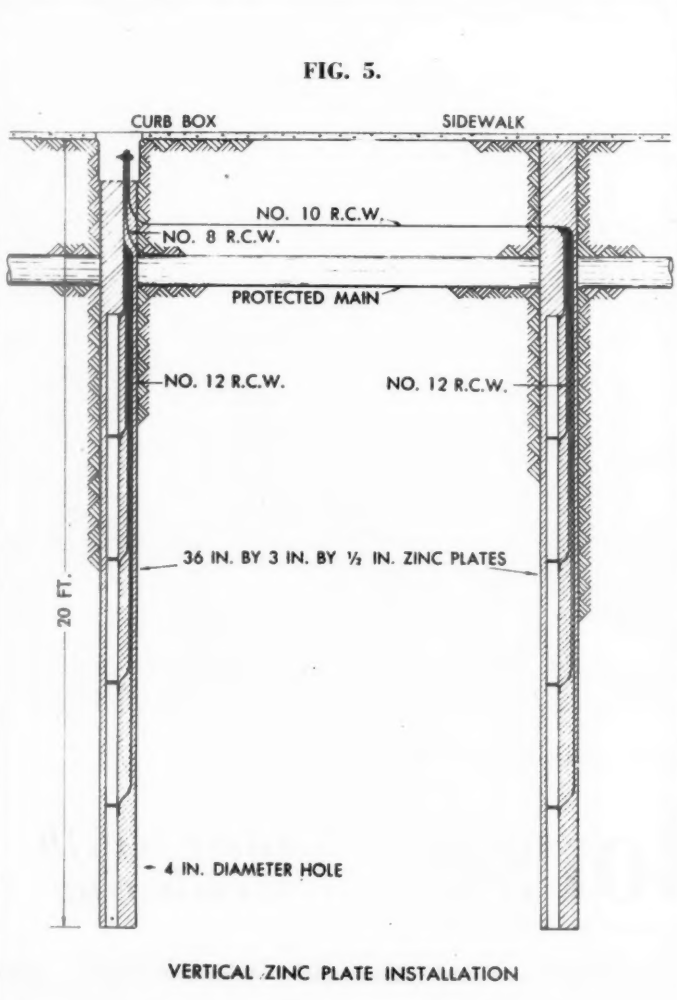
The lead wires from the main and zinc stack were connected by a split bolt connector in the terminal box usually situated behind the curb. This arrangement permitted observation of current output and potential of each stack of zinc plates. In a few cases leads from individual plates in the stack were carried to the curb box and marked so that division of current between individual plates could be determined. Table 2 shows the division of current between different plates in a vertical stack during wet and dry periods.

Obtaining necessary materials, tools, equipment and instruments for the work was difficult because of war restrictions, and a great deal of improvising was necessary. Insulating material and fittings were not available, and it was necessary to spend considerable time developing methods of insulating various connections. Contacts between the main to be protected and other structures were often very difficult to locate, and open couplings that required bonding were hard to find. Pipe locators and motor-operated interrupter buzzers to put tone or current on the line being investigated were used to find contacts and open couplings. An electric motor-operated mixer to provide a finely mixed backfill was used.

As this method of providing cathodic protection was unproved and, in some cases, might not prove to be a satisfactory and an economical method of protecting distribution mains, considerable attention was paid to obtaining complete records of data on all conditions and factors influencing the perfomance of zinc. This information, although expensive to obtain and maintain, will be valuable in determining future practices. The pipe-to-soil potential of each section of line protection is checked once each month, and abnormal conditions such as accidental contacts with foreign structures that have developed since the previous readings are disclosed by these readings. Records of potentials, current output, and resistances were obtained at the time each installation was made and at 3 to 6-month intervals thereafter; however, in some cases where a study is being made of the performance in various backfill mixtures or different methods of installation, more frequent observations are taken.

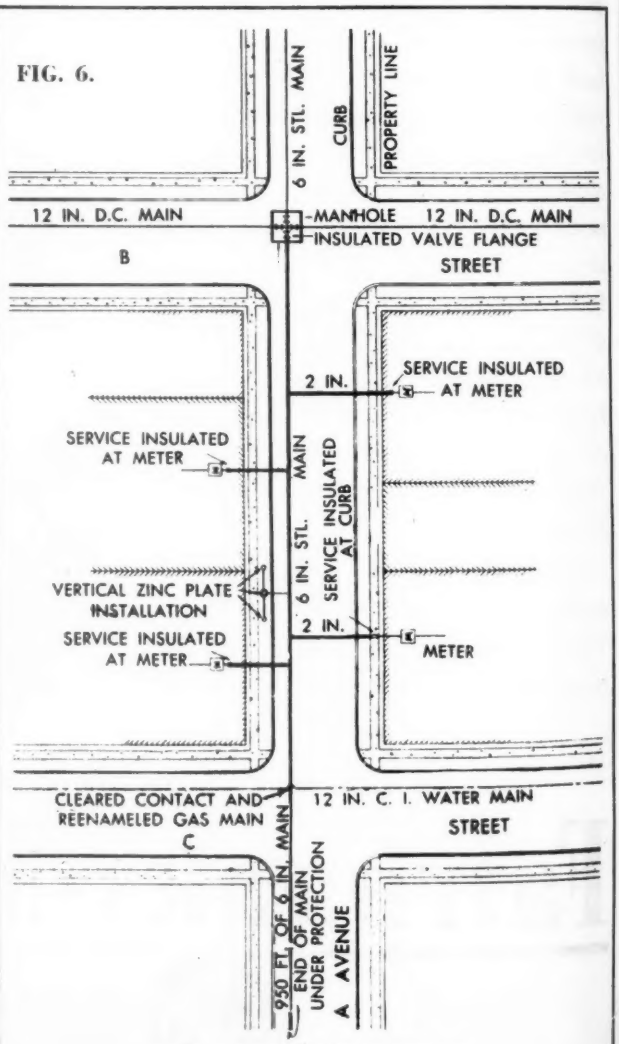
Actual cost of a cathodic program is difficult to ascertain. The work of applying cathodic protection was often done at the same time and by the same crews doing other work. It was therefore necessary to divide the expense between several different jobs, and it is difficult to do this accurately. It is also a problem to determine how much of the research and investigation expense and how much of the expense of designing and assembling instruments and equipment shall be included with the cost of each installation. An attempt has been made to determine a reasonably accurate cost of doing the work. This cost is obviously most important because even though the results are satisfactory, the cost might be prohibitive. After careful analysis of all the expense involved in the installation of protection, it was found that the average cost of protecting a mile of 6-in. pipe in the business section of Houston by the method described above is $2000. This cost includes all expenses incurred from the first preliminary survey until installations are completed and in operation. Additional information regarding

FIG. 5.



VERTICAL ZINC PLATE INSTALLATION

FIG. 6.



PLAN OF TYPICAL ZINC ANODES

cost of applying cathodic protection, using zinc, is given in Table 3.

There does not seem to be any universally accepted criterion to determine when complete protection is obtained. An attempt was made to maintain a potential of 0.85 volts or more between the main and a remote Cu SO_4 electrode. Numerous tests were made that indicated that this value was necessary to insure protection of mains from corrosion. The water system was also used as a reference structure in measuring potential. This reference structure is more convenient in the business section where water mains are readily accessible. It is often impossible to get a ground connection in the business section unless a long wire is strung out on the sidewalk, creating a hazard to pedestrians. The potential between protected main and the water pipe is generally 0.25 to 0.40 volts. The water system consists mainly of large diameter cast-iron pipe.

CATHODIC protection, using zinc as a current source, has been applied to all intermediate pressure steel welded main in business sections of Houston and to a number of sections of main in the outlying areas. A number of these installations have been in operation almost three years, and results obtained to date are highly satisfactory. Protection to all mains in the business section was completed in the early part of 1944. No corrosion leaks occurred on any of these lines during the year of 1944, and only one leak has been found through July, 1945, although an average of 19 corrosion leaks each year were found and repaired in the years of 1941, 1942, and 1943. The cumulative leak record of mains now protected in the downtown section of Houston is shown in Fig. 1. Although complete protection to these lines may have been obtained, an occasional leak may develop because there probably are a number of deeply corroded places on the mains that may result in leaks as the pipe is vibrated by street traffic, disturbed by soil stress, or strained when internal gas pressures on the mains are increased.

Performance of the zinc has been satisfactory. The zinc potential has not lowered materially and current output of plates backfilled with a gypsum-clay mixture has remained stable. A number of plates with complete records of their current output have been removed, cleaned, and weighed and their efficiency was found to average about 90 per cent. The plates were uniformly corroded over their entire surface except under the enamel strip. The regular character of corrosion is largely the result of uniform environment provided by the well-mixed backfill. Table 4 shows weight loss and current efficiency data of plates removed.

Experience to date indicates that old, poorly coated mains may be cathodically protected with zinc, provided the mains are completely insulated from all metallic structures, the proper backfill is provided for the zinc, and the zinc is buried sufficiently deep to be in permanently moist soil. Although a number of backfill mixtures for zinc are being tested, the gypsum-clay mixture seems to be best; but it is possible that some other mixture may be found later that will be even more satisfactory. Some advantages of gypsum as a chemical treatment for zinc backfill are low cost and general availability of gypsum plaster in 100-lb. sacks and the low solubility of the material, which greatly reduces the tendency to leach away.

The predominant compound in corrosion products of zinc anodes that have been excavated is zinc carbonate. This compound was predominant in corrosion products of plates that were backfilled with a gypsum-clay mixture as well as of plates backfilled with natural clay only. In the case of gypsum backfill, however, products of corrosion appear to be more porous than with other backfills, and the tendencies of the anode to polarize or to increase in resistance to earth is negligible compared with those observed on anodes backfilled with natural clay or with other materials tested.

The difficult and most expensive part of applying protection is insulating the main; and once this is accomplished, even though the zinc should become passive after a few years and fail to deliver sufficient current for protection, additional anodes can be installed at relatively low cost or other current sources can be used to continue the protection.

ALTHOUGH the work to date has dealt principally with poorly coated mains and with zinc as a current source, some work

(Continued on Page 208)

TABLE 1

Zinc anode performance with various backfills.

Number months connected	Backfill, clay mixed with	Current output per plate, milliamperes: Average for period	Current output per plate, milliamperes: At end of period	Average solution potential of zinc, volts*	Average resistance to earth, ohms.
	Test plates† at 4-ft. depth				
23	Gypsum plaster	55	61	1.09	5.1
16	Gypsum plaster, sand, and $MgSO_4$	45	38	1.09	5.7
16	Gypsum plaster and zinc SO_4	45	46	1.09	6.2
16	Gypsum plaster and sand	37	34	1.08	6.2
23	Clay	30	20	1.06	8.4
23	Ammonium chloride	18	2	0.95	8.7
15	Lime	6	..	0.82	8.0
	Average per plate of 10 installations on operating gas lines (4 or 5 plates in group)				
20–23	Gypsum plaster	29	..	1.09	1.54‡
20–23	Clay	18	..	1.06	1.84

*Measured to copper sulphate electrode. †Tied to water system. ‡Resistance of group.

TABLE 2

Division of current among the plates in a vertical stack of 5 zinc plates.

Current produced by each plate in per cent of the total for the stack

Plate number		Location A: Dry weather, per cent	Location A: Wet weather, per cent	Location B: Dry weather, per cent	Location B: Wet weather, per cent	Location C, Stack No. 1: Dry weather, per cent	Location C, Stack No. 1: Wet weather, per cent	Location C, Stack No. 2: Dry weather, per cent	Location C, Stack No. 2: Wet weather, per cent
(Top plate)	1	16.0	14.3	9.0	19.6	11.2	21.0	14.0	19.0
	2	11.2	12.2	22.0	19.6	18.0	19.0	19.2	20.5
	3	16.0	17.0	22.0	18.2	20.0	19.0	22.0	20.0
	4	18.2	15.7	19.5	18.6	21.0	21.7	22.5	21.0
(Bottom plate)	5	38.5	41.0	28.5	24.7	27.0	21.7	21.0	21.0
Resistance to earth of stack, ohms		1.72	1.70	1.22	1.20	1.26	1.29	1.37	1.36
Depth of boring		18 ft.		19 ft.		19 ft.		19 ft.	

Note: Plates were insulated from each other in the stack by a strip of enamel on the top of each plate, and separate leads from each plate were brought to curb box at surface.

TABLE 3

Information on estimated cost of installing zinc cathodic protection to gas distribution mains.

Class of main	Average size, in.	Amount of main pipe, ft.	Estimated cost to replace	Cost of repairing leaks occurring in 1941-42-43	Cost of applying Cathodic protection
Class A	6	24,000	$102,480	$5,600	$9,080
Class B	4	10,225	13,085	....	230
Class C	6	7,800	16,714	....	214

Class A. Mains are located in the business section, are all under pavement, and have numerous service connections. These mains were installed in 1927-1930, and they have poor coating. The service pipe connected to these mains was also protected; however, the length of pipe included in the services or the cost of repairing the service leaks that have occurred is not included. This is the most expensive class of mains to protect in the entire system on account of the difficulty in insulating the main.

Class B and C. Mains are located in outlying sections where no paving is involved. There are very few service connections, and the coating on the pipe is good. These classes of main can be protected at the lowest cost of any in the system.

Typical installation of 1600 hp gas engine-compressors

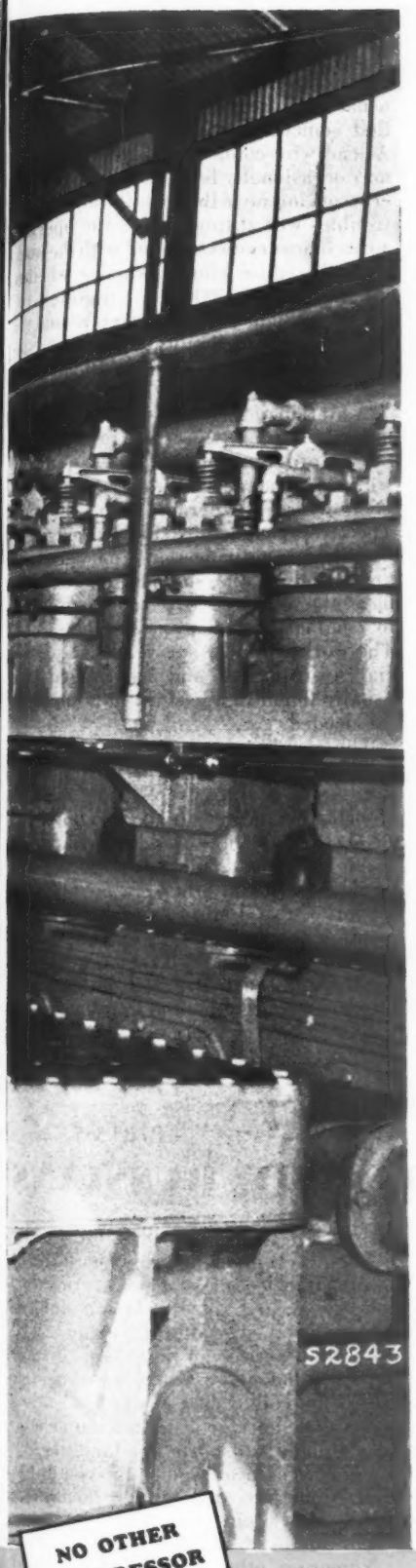


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TABLE 4

Current efficiency of zinc anodes.

Results of current output and weight-loss measurements on excavated zinc plates

Plate number	Days in service	Average current output ma	Ampere hours	Theoretical* weight loss	Actual weight loss	Per cent efficiency theoretical loss / actual loss
2-1	284	40.5	276	0.745	0.81	92
W-7	304	55.2	404	1.08	1.34	81
W-8	304	49.5	362	0.97	1.09	89
S-1	512	39.5	487	1.32	1.4	93
M-1	653	29.5	464	1.25	1.5	83
M-4	653	35.0	550	1.48	1.5	98
					Average	89

*Theoretical weight loss for zinc is 1 lb. for 372 ampere hours output.

TABLE 5

Operating data on some of the lines under protection in Houston.

Line	No. of zinc installations	Total no. zinc plates	Zinc output, milliamperes		P/S† volts	Length of pipe* protected, ft.	Pipe area, sq. ft.	Average ma per sq. ft.	Current ma per 1000 ft.
			Total	Per plate					
A	3	25	595	24	0.866	1,490	2,356	0.253	400
B	5	52	1242	24	0.923	2,910	4,424	0.281	427
C	5	50	1303	26	0.904	4,500	4,921	0.265	290
D	5	55	1322	24	0.912	6,500	7,945	0.167	204
E	5	52	814	16	0.908	3,930	4,018	0.202	207
F	1	8	110	14	0.960	780	1,229	0.089	141
G	2	20	382	19	0.885	985	1,641	0.233	388
H	1	12	230	19	0.93	10,225	12,000	0.019	23
I	8	156	2990	19	0.85	9,810	12,950	0.231	305
J	1	7	90	13	1.01	7,000	12,000	0.0075	13

*Pipe size 2-in.-8-in., service pipe not included.
†Pipe-to-soil potential measured to remote Cu SO_4 electrode.

(Continued from Page 205)

has been done on completely bare lines, well-coated lines, and with metals other than zinc as a source of current. Bare lines are most difficult to protect and, of course, require considerably more current than poorly coated lines. Well-coated lines require very little current. A 4-in. enameled and asbestos felt-coated line two miles long that was laid in 1934 is being protected with zinc plates having a total output of 230 milliamperes. Table 5 shows operating data on a number of lines under protection in Houston. It will be observed that current requirements on some of the lines are so small that substantial lengths of line are readily protected with a few zinc plates.

Magnesium, magnesium alloys, aluminum, aluminum alloys, and zinc of different purity are being tested. Some of these have certain advantages over the zinc used and may prove satisfactory as a current source for cathodic protection.

Zinc used as a current source of cathodic protection cannot be connected to the pipe, buried, and forgotten if beneficial results are to be obtained. It is not that simple. Frequent tests and inspections are necessary to detect trouble that may develop on the installation, impairing its operation. The trouble must be detected and eliminated as promptly as possible. The principal source of trouble is development of contacts between protected mains and other structures. Unusual and freakish contacts will occur that sometimes will be difficult to find. A lead wire connecting zinc to the main may occasionally be disconnected by others working near the installations. These troubles will at times cause the operator to become very discouraged with the work and will cause him to wonder whether the method is worthwhile; however, the troubles can usually be corrected and the method can no doubt be improved by continuous study, investigations, and hard work.

Adoption of an extensive cathodic protection program is a serious undertaking. Such a program should not be attempted without assistance from competent engineers who are experienced in this work. The average gas distribution engineer does not usually possess the necessary knowledge of the subject, nor does he have the required experience properly to conduct such a program unassisted. The work is highly specialized, and special instruments and equipment not usually found in a gas distribution plant are needed.

The results obtained with zinc as a current source to apply cathodic protection to old poorly covered steel main in Houston are very satisfactory to date. Protection is being extended to other old mains in Houston and to old steel distribution systems in other towns. The protection is also used to supplement treatment on new mains. Very careful checks are maintained on all installations in service, and time will reveal the measure of success of the method employed.

★★★

P 815.5

NEW ANTIKNOCK COMPOUND REPORTED BY RUSSIANS

An aviation gasoline component "twice as efficient as isooctane" is being produced from turpentine in the U.S.S.R., it is reported in the Russian scientific literature, which is translated and reviewed by J. G. Tolpin, editor of the U.O.P. Survey of Foreign Petroleum Literature.

It is stated that this antiknock compound, which is named "Uratol," resulted from the research of V. G. Plyusnin in the Ural division of the Academy of Sciences, and was produced in large-scale laboratory equipment as early as 1943.

The statement is made that turpentine also is employed to some extent as a regular motor fuel for trucks, tractors and other motorized equipment used in the lumber industry, although its principal present function seems to be to start engines which operate on producer gas.

According to one author, the use of turpentine as a motor fuel presents considerable difficulty, particularly with respect to acidity and gum, and larger carburetor jets are necessary because of the higher viscosity of turpentine as compared to gasoline. Furthermore, means for preheating the fuel-air mixture to 60°C. are required. Another author, however, states that Soviet-made tractor engines designed for gasoline require no changes in order to burn turpentine.

At any rate, the reports make it clear that the possibilities of wider and more satisfactory utilization of turpentine as a motor fuel are being studied. Cracking of turpentine is one method being investigated.

Another product of research in wood chemistry is a lubricating oil made from wood tar fractions. It is stated that more than 100 commercial units to produce such lubricating oils were under construction in 1943 in various parts of Russia.

These developments are the result of a campaign begun long before the war, and accelerated since 1941 to establish other sources of motor fuel and lubricants than petroleum, in various distant parts of the country where gasoline and lubricants could not be supplied, either because of shortage of petroleum or lack of adequate transportation facilities.

Industries located in or beyond the Ural Mountains naturally turned their attention to their forests, which supply turpentine in abundance.

Numerous other byproducts of wood are also being manufactured, some of which had previously not been made in Russia. Production of a synthetic resin from pine lignin and acetylene is presently in the development stage. Extensive research on the preparation of other new wood derivatives is going forward.

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Structural Changes in Carbon and Molybdenum Steels During Prolonged Heating at 900-1000 °F. as Affected by Deoxidation Practices*

G. V. SMITH, R. F. MILLER, and C. O. TARR
Research Laboratory, United States Steel Corporation

ENGINEERING structures used for prolonged service at elevated temperatures are usually designed on the basis of creep or stress-rupture data, which are obtained in tests of short duration relative to the service life. These properties depend upon the microstructure of the metal, and inasmuch as metals undergo changes in microstructure when held at elevated temperature, the creep and stress-rupture strengths in reality vary continuously, generally decreasing, throughout the service life. It is therefore desirable to study the microstructural changes occurring over longer periods at the temperature of interest, or as simulated, though not always equivalently, by shorter tests at higher temperatures. Accordingly, a number of samples, (Table I) comprised of three carbon (0.1 per cent) steels of similar composition but deoxidized differently, and six molybdenum steels (0.1-0.2 per cent C, 0.5 per cent Mo) similar except for silicon content and mode of deoxidation, were tempered for periods ranging up to 5000 hr. at 900, 1000, or 1100°F; and observations were made of (a) hardness (measured at ordinary temperature), (b) microstructure, particularly with respect to the progress of spheroidization and the possible occurrence of graphite. All but one steel were of commercial manufacture, as commonly used for elevated temperature service, and each was tested in two initial conditions, annealed and normalized.

● **Results.** The hardness of most of the carbon steel samples first increased slightly with time at temperature, then decreased slowly at about the same rate at each of the three temperatures; the changes appeared to be uninfluenced by the deoxidation practices used. The increase was greatest in the annealed samples held at 1000°F. The hardness of the annealed molybdenum steels followed the general pattern of the carbon steels, but the normalized samples behaved in a way characteristic of precipitation-hardening systems — that is, the hardness increased initially, more slowly but to a higher value the lower the temperature, and then decreased. This phenomenon combined with the simultaneous spheroidization and agglomeration of the carbide makes the picture of the hardness change less simple than for the carbon steels and annealed molybdenum steels.

The rate of spheroidization of the normalized steels was generally greater than for the annealed steels, as is to be expected from the finer initial structure, but the effect was less marked in the carbon steels. In the normalized carbon steels the rate was highest in the high titanium-treated steel. In the molybdenum steels the rate increased with increasing silicon plus aluminum addition, whereas a large aluminum addition without silicon was associated with a lower rate which, however, is probably to be attributed to a coarser initial microstructure.

Graphite formed in all the carbon steels, and at about the same rate in both normalized and annealed specimens. In the 6 molybdenum steels, it formed only in the three to which aluminum had been added; in these 3 the rate seemed to be faster the higher the silicon content, and in the annealed rather than in the normalized samples, only one of which showed graphite. In both groups graphitization was generally faster the higher the temperature within the range studied.

A great deal of further work is needed, particularly on the nature of carbides, how they depend on the presence of alloying elements, whether added as such or as deoxidizers, and how the carbides are modified by temperature and time. Obviously, therefore, many of the outstanding questions can not be answered in the immediate future.

● **Initial heat treatment.** Since commercial practices usually involve air cooling (normalizing) or furnace-cooling (annealing) from the austenitizing temperatures, each steel was treated in both manners. An austenitizing temperature of 1650°F. for the molybdenum steels and 1600°F. for the carbon steels was used; specimens were held at temperature one-half hour before cooling. The molybdenum steels were treated in the form of small bars approximately ½ in. by 1½ in. in cross-sections, and the SAE 1015 steels as 1-in. rounds. Air cooling was accomplished by removing the bars (4 to 6 in. in length) from the furnace and setting them on end on refractory bricks; the end in contact with the brick was discarded.

● **Tempering.** In most elevated temperature service such steels are used at temperatures under 1100°F., and in fact, mostly below 1000°F.; with this in mind, tempering temperatures of 900, 1000, and 1100°F. were chosen. Tempering periods were 5, 15, 50, 100, 300, 500, 1000, 3000 and 5000 hr., a separate specimen being used for each period.

● **Hardness measurements.** Vickers hardness (20 kg. load) was measured in investigating the results of tempering. Not all specimens were examined in this way, but in general only those needed to determine temperature-time hardness trends. The semi-log plot was chosen for convenience and because many solid-state reactions proceed in such a fashion that the semi-log plot is linear. Departure from a straight line, therefore, may be taken as an indication of the occurrence of effects other than simple spheroidization. (Curves may be procured from ASTM preprint if desired.)

● **Carbon steels.** The several steels show a similar variation in hardness with time at temperature, i.e., hardness decreases with increasing time beyond 5 hr., in an approximate, though not exact, linear manner on the semi-logarithmic scale. Graphitization, detected metallographically in the specimens tempered for the longer periods, evidently had not progressed sufficiently to affect the hardness.

A curious fact is the seeming independence of the rate with respect to temperature and the small differences in hardness developed at different temperatures. Another curious observation, in a few of the normalized and in all the annealed specimens, is the increase in hardness over that of the original caused by the 5-hr. tempering; this is particularly evident in the annealed steels in which some increase is retained up to 1000 hr. at temperature. This indicates that some process other than simple spheroidization is occurring. The effect, perhaps a precipitation hardening, appears to be greatest at 900°F. in the normalized samples and at 1000°F. in the annealed samples, and is great enough to cause the hardness of the annealed samples, which initially was some 15 points softer, to increase to a level comparable with that of the normalized series. The effect of larger aluminum addition with simultaneously smaller titanium addition is not large enough or clear enough to warrant discussion.

● **Molybdenum steels.** In molybdenum steel, something other than simple spheroidization occurs at elevated temperature, but for this there is a ready explanation. On tempering such steels a fine ground-mass precipitate develops, appearing earlier the higher the temperature, and coarsening with time at constant temperature, both in the manner of a typical precipitation-hardening

*Condensation of paper prepared for American Society for Testing Materials. Complete paper may be procured upon application to ASTM., 260 South Broad Street, Philadelphia 2, Pa.

TABLE 1. Analysis and deoxidation practice. (Table 2 omitted from condensed version.)

No. of steel	Type of steel	C	Mn	P	S	Si	Cu	Cr	Mo	Ti	Zr	Al	Al_2O_3	Deoxidizers added*		After carburizing test ASTM grain size	Structural normality
														Ladle lb. per ton	Mold, lb. Al per ton		
1	Mo	0.16	.84	0.020	0.027	0.47	0.02	0.03	0.48	..	..	0.039	0.009	.9 Fe Mn 12.6 Fe Si	1.0	6–8	Moderately abnormal
2	Mo	.16	.84	.019	.030	.47	.03	.03	.47	..	..	.006	.003	.9 Fe Mn 12.6 Fe Si	0.0	2–4	Slightly abnormal
3	Mo	.20	.84	.026	.026	.22	.02	.02	.48	..	..	.005	.006	.9 Fe Mn 7.7 Fe Si	0.0	2–3	Slightly abnormal
4	Mo	.21	.85	.024	.026	.23	.03	.01	.48	..	..	.035	.005	.9 Fe Mn 7.7 Fe Si	1.5	6–8	Moderately abnormal
5	Mo	.20	.73	.031	.031	.23	.04	.24	.51	..	.04	.004	.004	5.1 Fe Si Zr	0.0	2–4	Normal
6	Mo	.11	.46	.009	.012	.02	..	.17	.43	..	..	.084	.009	0.0 Fe Si	3.0	7–8	Moderately abnormal
7	C	.13	.45	.011	.023	.19	..	..	..	0.001	..	.007	.003	10.0 Fe Si 0.0 FeCTi	1.0	2–4	Slightly abnormal
8	C	.14	.47	.008	.002	.21	..	..	..	.003	..	.004	.002	10.0 Fe Si 4.0 FeCTi	0.5	1–4	Slightly abnormal
9	C	.14	.46	.009	.028	.19	..	..	..	.002	..	.005	.002	10.0 Fe Si 6.0 FeCTi	0.0	3–4	Slightly abnormal

Note: Ni and V were nil in steels 1-5 and not determined in the remainder.
*The manganese content of the ferro-manganese was in all cases 80 per cent.
The silicon content of the ferro-silicon was 80 per cent for steels 1 and 2, and 50 per cent for steels 3 and 4.
The ferro-silicon, zirconium has 52 per cent silicon and 30 per cent zirconium.
The analysis of the deoxidizers used for the remaining steels is not known.

TABLE 3. Progress of spheroidization and of graphitization, as observed after 5, 15, 50, 100, 300, 500, 1000, 3000 and 5000 hr. at temperature.

No. of steel	Type of steel	Main deoxidizers added		Hours to reach stage of spheroidization									Hours to reach stage of graphitization (Blank spaces indicate none detected within 5000 hr. at temperature)								
		Ladle, lb. per ton	Mold, lb. Al per ton	900 °F.			1000 °F.			1100 °F.			900 °F.			1000 °F.			1100 °F.		
				Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Normalized specimens																					
1	Mo	12.6 Fe Si	1.0	100	3000	*	5	1000	3000	5	15	100									
2	Mo	12.6 Fe Si	..	3000	*	*	5	500	3000	5	50	300									
3	Mo	7.7 Fe Si	..	5000	*	*	100	3000	5000	50	300	500									
4	Mo	7.7 Fe Si	1.5	5000	*	*	50	500	1000	5	50	300									
5	Mo	5.1 Fe Si Zr	..	3000	*	*	500	1000	3000	50	100	300									
6	Mo	....	3.0	5000	*	*	1000	3000	5000	100	300	1000				5000	*	*	3000	*	*
7	C	10.0 Fe Si 0.0 FeCTi	1.0	1000	3000	5000	50	500	1000	15	50	300				5000	*	*			
8	C	10.0 Fe Si 4.0 FeCTi	0.5	300	1000	3000	100	500	1000	5	50	300				5000	*	*	1000	*	*
9	C	10.0 Fe Si 6.0 FeCTi	0.0	50	500	1000	5	500	1000	5	15	50					5000	*	5000	*	*
Annealed Specimens																					
1	Mo	12.6 Fe Si	1.0	5000	*	*	300	1000	3000	15	100	300	5000	*	*	1000	3000	5000	300	1000	5000
2	Mo	12.6 Fe Si	..	5000	*	*	500	3000	5000	15	100	500									
3	Mo	7.7 Fe Si	..	5000	*	*	300	3000	5000	100	300	1000									
4	Mo	7.7 Fe Si	1.5	5000	*	*	50	300	5000	5	100	500				3000	*	*	1000	3000	*
5	Mo	5.1 Fe Si Zr	..	5000	*	*	300	3000	*	50	300	500									
6	Mo	....	3.0	5000	*	*	500	*	*	100	300	1000				5000	*	*	1000	*	*
7	C	10.0 Fe Si 0.0 FeCTi	1.0	5000	*	*	50	300	1000	15	100	500				5000	*	*			
8	C	10.0 Fe Si 4.0 FeCTi	0.5	5000	*	*	50	300	500	15	100	500				5000	*	*	3000	*	*
9	C	10.0 Fe Si 6.0 FeCTi	0.0	300	*	*	50	300	1000	15	50	300				3000	5000	*		3000	*

*Greater than 5000 hr. (limit of observation).

system. Correspondingly, the change is reflected in the hardness. Owing to this precipitation, it becomes difficult to separate the effect of precipitation from that of spheroidization and agglomeration.

The effects of agglomeration and of precipitation cannot be distinguished. Evidently the hardness as determined represents some sort of average of the hardening due to the ground-mass precipitate and the softening that accompanies spheroidization and agglomeration of the carbide and of the precipitate. At the lower temperature, hardening predominates; at the higher, softening predominates.

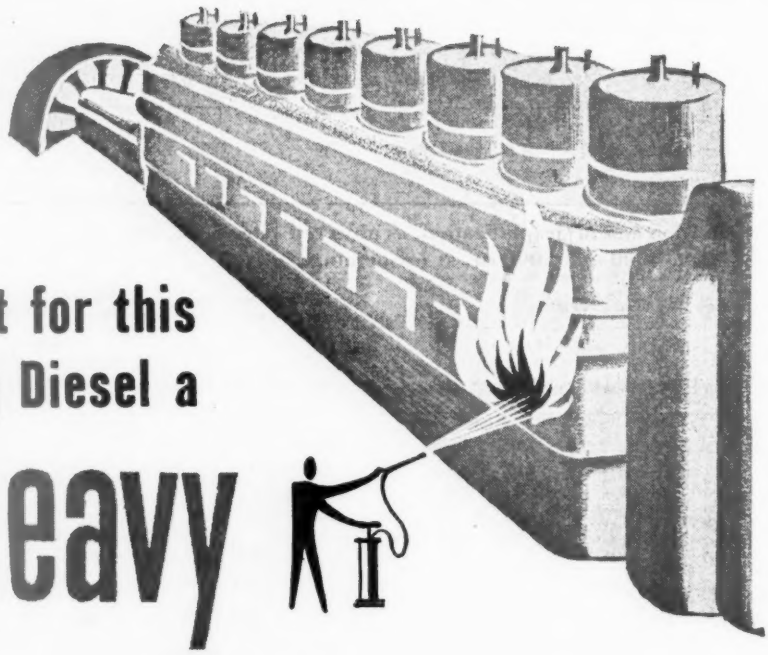
The annealed samples all show much less evidence of either softening or hardening than the normalized. The reason for this may be that equilibrium is more nearly attained during the slower cooling, while the lesser softening may be attributed to the coarser carbide which likewise results from slower cooling. It may also be noted that, as in the annealed carbon steels, short tempering of the annealed samples increases hardness. With respect to the effect of aluminum on the retention of hardness, comparisons for steels 3 and 4 and for steels 1 and 2, at the "low" and "high" silicon levels, respectively, show in both, that aluminum addition lowers the hardness of normalized material, and that this difference is preserved during tempering.

The effect of varying silicon cannot be evaluated owing to other differences in composition. For example, of the three steels (2, 3 and 5) to which no aluminum addition had been made, steel 5, with the lowest silicon addition, had the greatest hardness in the normalized condition and best retained hardness on tempering at each temperature; but the silicon was added as Fe-Si-Zr and there was an appreciable chromium content. The behavior of the annealed samples is not in conformity with the relationship noted for the normalized samples, though the spread is of a minor nature and probably not significant.

● **Initial structures.** The greatest difference is found between the annealed and the normalized states. The molybdenum steels were more noticeably affected by variation in deoxidation practice, particularly in the normalized condition. As in the carbon steels and for the same reasons, the furnace-cooled samples spheroidized more slowly than the normalized. Moreover, as a whole, the molybdenum steels were more resistant to spheroidization owing, perhaps, to the necessity for diffusion not only of carbon, but also of molybdenum, a process that occurs at an appreciably slower rate than for carbon.

Three arbitrary stages of spheroidiza-

For a small motor fire which might build up to a big blaze a one quart is ample protection.



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tion and graphitization were established: (1) First detectable change; (2) intermediate; (3) advance change. The time required to reach these stages is shown in Table 3.

● **Graphitization.** It is interesting to note that the three molybdenum steels that graphitized were those to which aluminum had been added in the mold, and of these three, that with the highest silicon, number 1, graphitized to the greatest extent, and that with the lowest silicon, number 6, least (in spite of having the large aluminum addition of 3 lb. per ton). It is also interesting, and perhaps unexpected, that graphitization proceeded more extensively in the annealed than in the normalized specimens. In fact, only in steel number 6, which incidentally contained an appreciable chromium residual, 0.17 per cent, was graphite detected in the normalized molybdenum steels. The use of titanium as a stabilizer of carbide and graphite inhibitor is under investigation at the present time.

In the carbon steels, the extent of graphitization or the time for its appearance was apparently independent of initial conditions, i.e., whether normalized or annealed, and no clear relation to deoxidation practice is apparent. In both series, graphite appears generally to form faster the higher the temperature within the range studied.

In this connection it has been suggested that the type of structure developed in the carburizing test may be indicative of susceptibility to graphitization according to the following scheme: Steels that show a so-called "abnormal" structure are prone to graphitize, whereas those that show a "normal" structure are resistant to graphitization. It is apparent that for the molybdenum steels there appears to be a correlation between graphitization tendency and degree of "abnormality." That is, those that graphitized within 5000 hr. (steels 1, 4 and 6) were steels to which aluminum addition had been made and which were both fine grained and "abnormal." Whether this is always the case, and whether "normal" steels are indefinitely resistant to graphitization, cannot be decided on the basis of our limited studies. It is suspected, however, that the apparent relationship can only come about through an accelerating effect of the aluminum addition (which tends to produce "abnormality") on the rate of graphitization, not on the thermodynamic stability of graphite relative to carbide.

The fact that spheroidization is apparently accelerated by aluminum additions and that (in the molybdenum steels) graphitization occurred only in steels to which aluminum had been added indicates some sort of relationship between the two phenomena. This does not mean, however, that spheroidization must precede graphitization. Perhaps aluminum addition serves to increase the diffusivity of carbon and thus spheroidization and graphitization, while the alumina particles resulting from deoxidation aid somehow in nucleating graphite. ★★★

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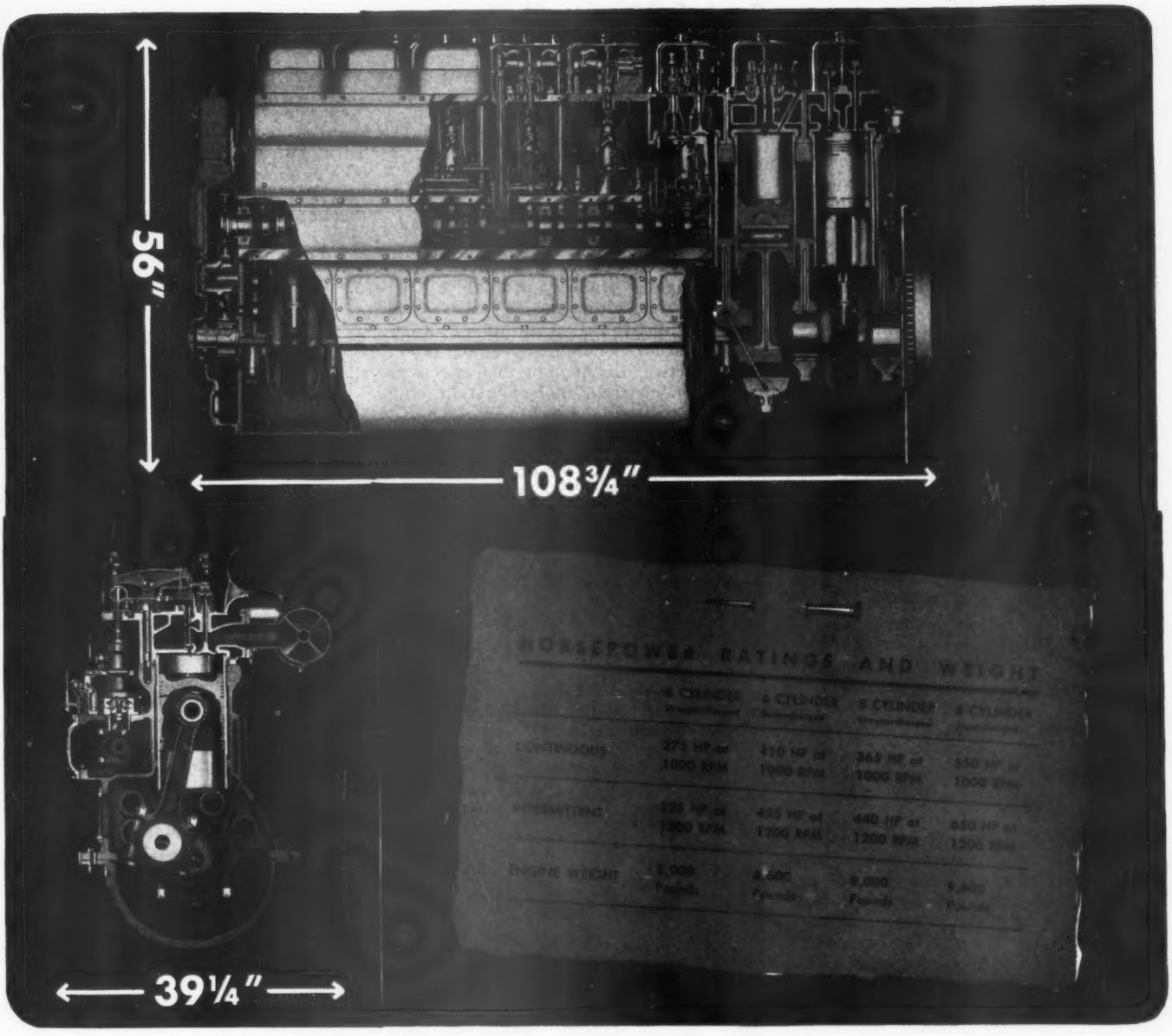

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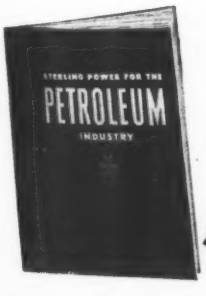

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An increasing number of wells are being reconditioned effectively with ordinary glass marbles propelled by the explosion of nitroglycerin placed in a 1½-in. tube in the center of a torpedo. About 500 oil and gas wells in the various producing states have been shot with these "agate" torpedos* since the idea was first tried early in 1944. The marbles are packed in the annulus between a 3-in. outside tube and the 1½-in. explosive tube. The tubes are made of tin in 5-ft. sections.

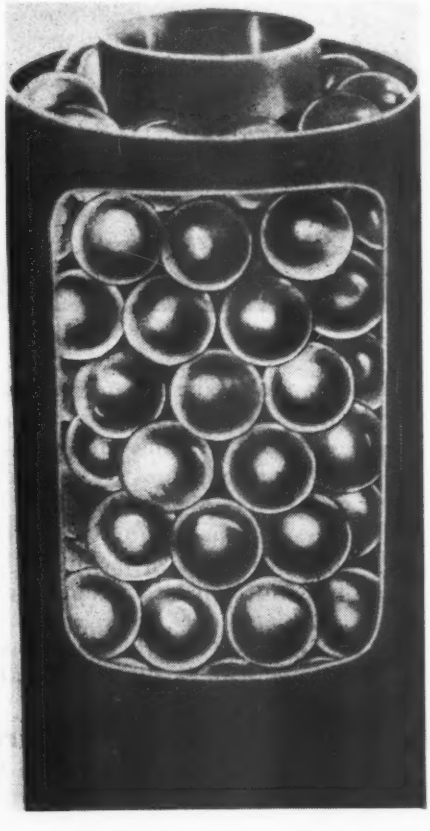
Few mechanical changes have been made in the tool since it was first devised, but it is planned to use seamless aluminum tubing for a 1⅝-in. O.D. by 5-ft. explosive container. This will hold exactly two quarts of explosive per 5-ft. section. Rolled sheet aluminum will be used for the 3-in. O.D. by 5-ft. outside container. The annulus will hold 242 of the ⅝-in. glass marbles per linear foot. All accessories will be made of aluminum. Release of restrictions on the use of this metal have been announced, and fabrication of the new torpedo will begin soon.

● **"Necessity the Mother . . ."** In 1936 the writer was temporarily forced out of the oil production business by the loss of a 150-bbl-per-day well in Wheeler County, Texas. This well had been producing through a separator with barely enough gas for continuous flowing. It had been tubed for gas-lift, which was used for a short period every other day to relieve the increasing weight of the fluid column. A 5-day delay occurred, 2 of which the well remained dead, and, when the gas was turned into the tubing, the oil standing in the column flowed out, but no new oil came into the well. Knowing that the well was not depleted, the writer cleaned it out, treated it with hot distillates and hot water, steamed it, circulated solvents, and ran a scraper and a kick-off tool. It was extremely hazardous to shoot the well with even a small squib in this soft granite wash formation, but as a last and drastic effort shooting was tried. After the shot the well began caving, and cleaning out became only a mudding process. This well, which never made as much as 1 bbl. of oil afterwards, was lost from the lack of knowledge of an effective reconditioning treatment.

The idea that some way must be found to help wells not depleted but only congested was a challenge. Conventional tools were not always effective in cleaning, for they could not reach the irregularities of the walls caused from the deeper shattering of the more dense formations when shot with bulk explosives. The writer felt certain that if it were possible to take a hammer and chisel down a well bore and clean the wall back to the true formation, it would again produce profitably. He realized that although air with sand properly distributed made an effective sand blast for cleaning, air without sand is ineffective. He thought that effective results in cleaning wells might be obtained by using a small column of explosive to propel solids into the formation to reopen it for drainage, and that, without tremendous disturbance, congested formations might be cleaned regardless of irregularities.

● **Idea takes form.** The first tool designed after consultation with explosives engineers had a 3-in. liquid glycer-

Cut-away view of the side elevation showing marbles in tiers in the annulus between inner and outer shells and partial cross-sectional view of shells and marbles in place.



in container, a 4½-in. iron slug container with bullet-shaped plugs cast in 18-in. strips held together at their base by a thin webbing. This tool was very expensive, the weight almost prohibitive, with no means of connecting the sections to cover the pay zones in wells to be treated. Nevertheless, 12 wells were shot with fair results. Further experimenting revealed that flat-backed solids would not penetrate into the formation but would hit broadside by almost immediately beginning to turn around toward the explosion. In addition, the strips were not always separated into individual units by the explosive, although when dropped 3 ft. to the floor, separation was complete.

Cast-iron cylinders serrated as a hand grenade were tried, but almost regardless of how fragile the bonding, the explosive would break the casting into segments only. Much later the same idea was tried with marbles, but no advantage seemed to be gained in casting glass marbles with thin glass webbing. Round, unbonded iron balls were next tried. These gave a perfect pattern of hits, but the iron balls would penetrate various short distances and stay lodged in the formation giving only slight relief to congested conditions on the face of the formation. Much time was spent with the idea of driving a solid into the formation that would explode with a delayed action.

Experimental shooting in various kinds of vats indicated that where it has room to expand, an explosive has no breaking force when objects are placed tightly against the explosive, for the objects so placed become a part of the explosion and are propelled outward as projectiles yet unharmed at approximately the speed of detonation. If a watch crystal were placed against a column of explosive in a large body of water and the explosive detonated, it is doubtful that it would be broken.

Gravel was used as an experimental solid, but very few hits were obtained because the overlapping particles were pulverized against each other. It was determined, therefore, that the objects used should be round, unbonded, and in a single layer. Search was then begun for a material fitting those requirements plus the property of disintegrating after penetration with force enough to shatter the face of formation between the hits.

● **First marble torpedo developed.** It was not until early 1944 that the idea of marbles was conceived and tried. Some plain dime-store marbles were purchased. A hole about 14 in. in dia. was dug in black top soil, and the first "agate" torpedo was exploded. The walls of the hole, other than showing a regular pattern of hits, were not disturbed. After carefully peeling back the bank for several feet, the marbles were found still round but disintegrated to white sand by the heat of penetration. They had not changed in size and retained a gloss coating, but they could be pulverized easily by squeezing them with the fingers.

From many experiments much was

*The "Burch Agate Torpedo" was developed by the author.

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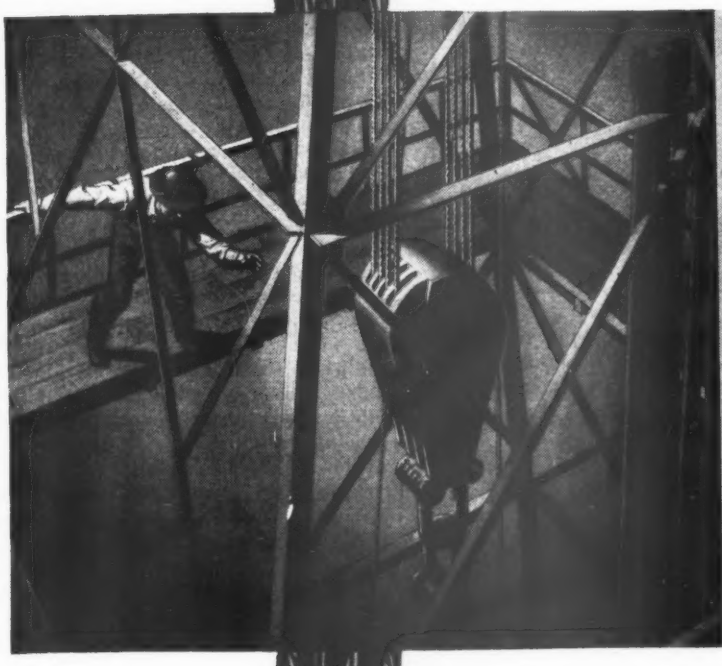

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learned about marbles. Common glass has a much greater crushing strength than any oil producing formations, and it is very elastic. A glass marble was thrown against seasoned concrete without breaking. Then, the shot in a shotgun shell was replaced with a marble and at distances of 15 to 25 ft. it was fired against seasoned concrete, and in no case did the marble break. Chips of cement the size of a saucer were knocked off, but the marble was unharmed. In a well where the marbles are propelled by nitroglycerin, however, the marbles reach the wall of the well with such high velocity that they penetrate even the hardest formation to some extent. When the resistance of the formation checks the speed of the marbles they disintegrate violently with a blasting effect toward the center of the well bore. The marbles erupt into particles of glass about the size of a pinhead. Evenly-sized heat-treated glass marbles are now being used to lace around the explosive container to avoid the slightest overlapping.

In shooting in shallow, large diameter, cement vats where the explosive gases could escape readily, the marbles alone destroy the surface of the solid cement to a depth of 2 in. The destructive force of the marble is even greater where the explosive gases are retained, as in a well.

● **First tried in edge wells.** As the purpose of these experiments was to find something to help congested oil and gas wells, an old edge well was offered for experimental purposes. It had been drilled in with a rotary. The pipe was set 25 ft. from bottom, and the hole had been bailed without a sign of oil or gas. The pipe was too close to shoot heavily. A 21-ft. marble torpedo loaded with 60 per cent dynamite was run in the 11-in. drilled hole. A 10-ft. section of solid wall formation in the bore was cleaned out. After shooting, the well made 8 bbl. of oil per day and the pipe was not damaged.

The next well shot with marbles was an oil well about to be abandoned. It had never been a good producer and was making less than 2 bbl. daily. It was shot with 20 ft. of marble torpedo and dynamite, and the production increased to 4 bbl. per day. The third well shot with marbles had been making 4 bbl. per day before shooting. It was shot with 35 ft. of torpedo and liquid glycerin (1½-in. column), and the production increased to 33 bbl. per day. The fourth well shot was positively a dry hole. It was torpedoed for practice only.

On wells where there was a large amount of formation shattered but interlocked on the wall of the shot hole caused from previous bulk shooting, the cleanout time was about three days; retreatment of the wells with the marble torpedo, however, drops the formation into the hole in such a condition that it can often be cleaned out in one day or less.

Material Statistics

Velocity in feet per second of different explosives:	
100% Nitroglycerine	23,600
80% Straight gelatin	21,600
60% Straight gelatin	19,700
Energy developed by one quart of 100% explosive	7,150,000 ft.-lb.
Energy developed by one linear foot of agate torpedo	2,500,000 ft.-lb.
Average crushing strength of various materials in pounds per square inch:	
Glass	27,582
Granite	11,000
Limestone	8,750
Sandstone	5,000
Dolomite	10,000

● **Marbles shred casing.** The first two marble shots were made up of hail screen with cast-iron male and female connections grooved and babbitted on the ends of the hail screen containers. A tin explosive container and a treated paper marble container were used on the first 120 wells shot with liquid glycerin. The paper container was replaced by one of tin after a mishap on a well in the Oklahoma City field. While trying to place the torpedo at 6700 ft., the torpedo stopped at 5800 ft. It was thought by the operator that the paper tube wore out from friction in running and that this caused the torpedo to stop short of destination. Because of this mishap, however, another use for the marble torpedo was demonstrated. After the torpedo stuck, a bailer was run and the torpedo exploded completely shredding the solid pipe but without junking any portion of the hole. There was no obstruction to interfere with the running of tools or producing at a lower depth, and a tin torpedo was run to the desired depth the next day. Before this, by experimenting on surface pipe from abandoned holes and different sized nipples buried at various depths, cemented and uncemented, the marble torpedo had indicated its ability to shred pipe. The marbles provided uniformity of the explosive's power, and the small amount of explosive used did not give a damaging reaction.

More than 30 pipe and liner shredding jobs have been performed to date. It is important to center the bomb in the casing to be shredded, and to insure this, section connections (collars) with wire alignment guides are supplied.

For a company that was having difficulty pulling a congested liner, a 5-ft.

Rigged up ready to run with double line on special pulley and proper shoe for setting torpedo on bottom. Anchor tip shoe is used when placing torpedo distances from bottom.

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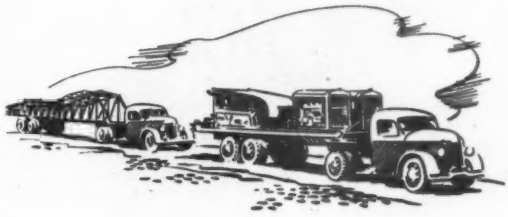

The power plant, drawworks, rotary table and drives on Franks Skid Rig may be moved in one section for inter-field moves. Where necessary, drawworks and power plant can be divided into two loads by driving out only four tapered pins in the main skid without disturbing guards or drives. For inter-field moves derrick may be left in one section with blocks strung and tongs hung. For longer moves the derrick may be quickly and easily disjointed in two or three sections. Assembly and disassembly of derrick is accomplished with minimum time and effort by means of tapered guide plugs designed for quick alignment and maximum rigidity.

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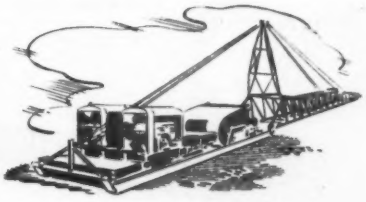
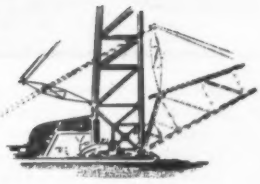
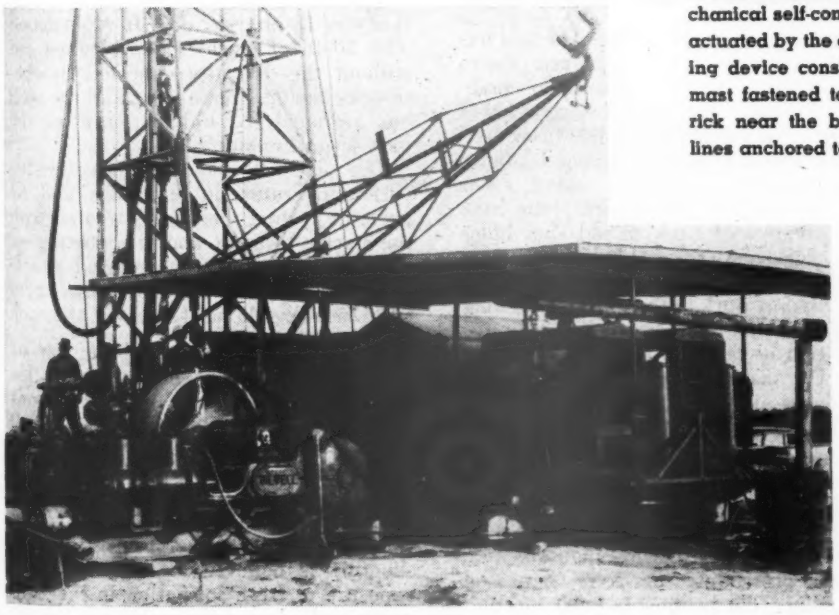


In a Franks Skid Rig there are fewer components to assemble since power plant, drawworks, rotary table and drives are integral parts of the main skid and are moved as one or two sections. If main skid has been divided into two loads it is easily reassembled with Franks patented pilot frame joint. One leveling operation levels the whole rig. The raising hinge shoes and socket provide a simple, safe, and convenient attachment of derrick to drawworks frame—no careful alignment, no hinge pins, no bolts necessary. Unit can be rigged up and drilling started within a few hours after reaching location.

• DERRICK RAISED IN 5 MINUTES





Franks Derrick is raised by a mechanical self-contained raising device actuated by the drawworks. This raising device consists of an "A" frame mast fastened to the rear of the derrick near the base, two double lift lines anchored to the end of the boom and to lift points on the derrick, and a five line block and line arrangement located between the end of the boom and an anchor point on the drawworks frame. A double hinge point raising arrangement has been incorporated to keep the center of gravity of the derrick always ahead of the hinge point, eliminating the use of a snubbing line while raising or lowering.

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Weight taken from the double pulley by pressure on the line between the conventional pulley and the truck, which leverage permits one man to lift several 100 lb. with ease. The space between top of torpedo and bail-equalizer on this particular shot is yet to be filled by bomb container.

section of the torpedo was run to bottom, picked up 10 ft. to be near the center of the last joint of the liner, and, after detonation, the liner was pulled freely, the pipe separating at the top of the shot. The 5-in. liner, at point of separation, was swelled to fit the 6-in. casing. A 70-ft. torpedo was run and anchored 15 ft. from bottom, the well thoroughly cleaned, and the liner re-run. It telescoped into the belled top of the section of liner left in the hole.

In a depleted oil well, gas was logged in an upper formation but was cased and cemented off during completion. The operator had ripped the pipe without obtaining as much as a million cu. ft. of gas. Shooting the well with 25 ft. of marble torpedo increased the flow to about 7 million cu. ft. of gas. In testing to determine the condition of that portion of pipe shot, tools were run freely.

● **Torpedo used for various jobs.** Commercial quantities of oil have been recovered behind 9-in. by 40-lb. heavily-cemented pipe. Tubing has been run within a day after shooting. The tool has been used effectively in damaged pipe to restore the pipe to a concentric condition. In wells that have been rat-holed deeper, the marble bomb has been used to increase the size of the small hole to accommodate liners. In many cases selected sections on squeeze jobs have been reopened. Junk in old shot holes has been side-tracked but the exact results of using the marble torpedo for this kind of work are not always predictable. The tool tends to provide even distribution of the explosive-propelled solids. The marbles tend to fit all objects with a regular pattern whereas an explosive alone may bypass some of the objects and spend its energy farther up or down the well. An explosive alone has a tendency to throw loose particles of pipe or liner from the walls, and is more practical for use in continuous fishing, but for protruding "donikers" bypassed in drilling, flat sections in holes, putting underreamers to work in drilled holes, and reconditioning key-seated holes, this tool supplies a uniformly radial pattern of explosive performance that may not be accomplished by using explosives alone.

Many formations tend to filter solids out of the fluids that pass through them. Salt water disposal wells and gas and water flood input wells sometimes become congested with solids. The congestion often builds on the face of the formation and not into it. Marble torpedos have been used to remove this sheath from the face of the well bore.

● **Old wells revived.** Some interesting results have been obtained in old fields where wells have been producing 30 to 40 years. One small well near Caney, Kansas, had been producing ½ bbl. per day for years. After treatment with the marble torpedo it has produced 8 bbl. per day. Another well near Drumright, Oklahoma, that had been producing a number of years was shot with a heavy load of liquid explosive 10 years ago, and production increased to 25 bbl. per day. Since then the production declined to 2 bbl. per day and the immediate producing area was put on vacuum. This well was shot with a marble torpedo 6 months ago. Initial production after shot was 50 bbl. per day, and settled production now is 31 bbl. per day. In New York State a 48-year-old gas well had declined to 10,000 cu. ft. per day. It was shot with a 5-ft. shell of marble torpedo, and the production was raised to 83,000 cu. ft. per day.

A granite wash well in a low pressure mud area in the Bowers pool of the Panhandle field became congested and paraffined to the point where further production was doubtful. The complete liner was cemented with salt and gypsum to the extent that it was dislodged and pulled with the tubing. The paraffin and salt made it impossible to see either the collars or perforations in the liner. After cleaning this well, there was only a slight increase of production due to the congested condition of the wall. The well's record prior to the above condition was 18 bbl. per day. It was treated with 80 ft. of marbles and cleaned out without the difficulty expected in continuous caving from a shot, and the well has averaged 132 bbl. per day for the past several months.

The sincerity and exactness of the various operators in separately and repeatedly testing their wells treated with the marble torpedo, and in reporting results to the writer over a period of one year, has supplied the experience needed to measure the usefulness of the tool.

● **Why wells are shot and the size of holes.** Shooting was first adopted for the purpose of opening pay formations with low permeability or congested wall faces. Well production has been helped by shooting primarily to the degree that the face of the formation has been increased in area and freed of encrustations. Most of the help derived from shooting is believed to stem from the exposure of fresh formation in the bore of the well. Less help is believed to accrue from the increased diameter of the well. Large gas and oil wells that flow continuously while being drilled in are helped but little by shooting compared to the help given wells that have been drilled in while loaded with mud-laden fluid. Most new wells are freed to various extents from congestion by swabbing and bailing after drilling in. In a very few open formations such as granite wash, the swabbing and bailing may

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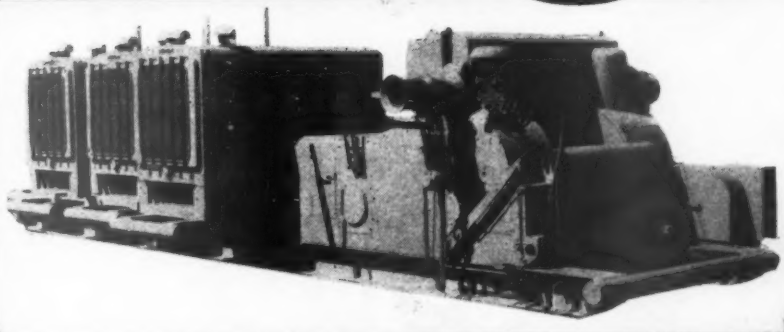

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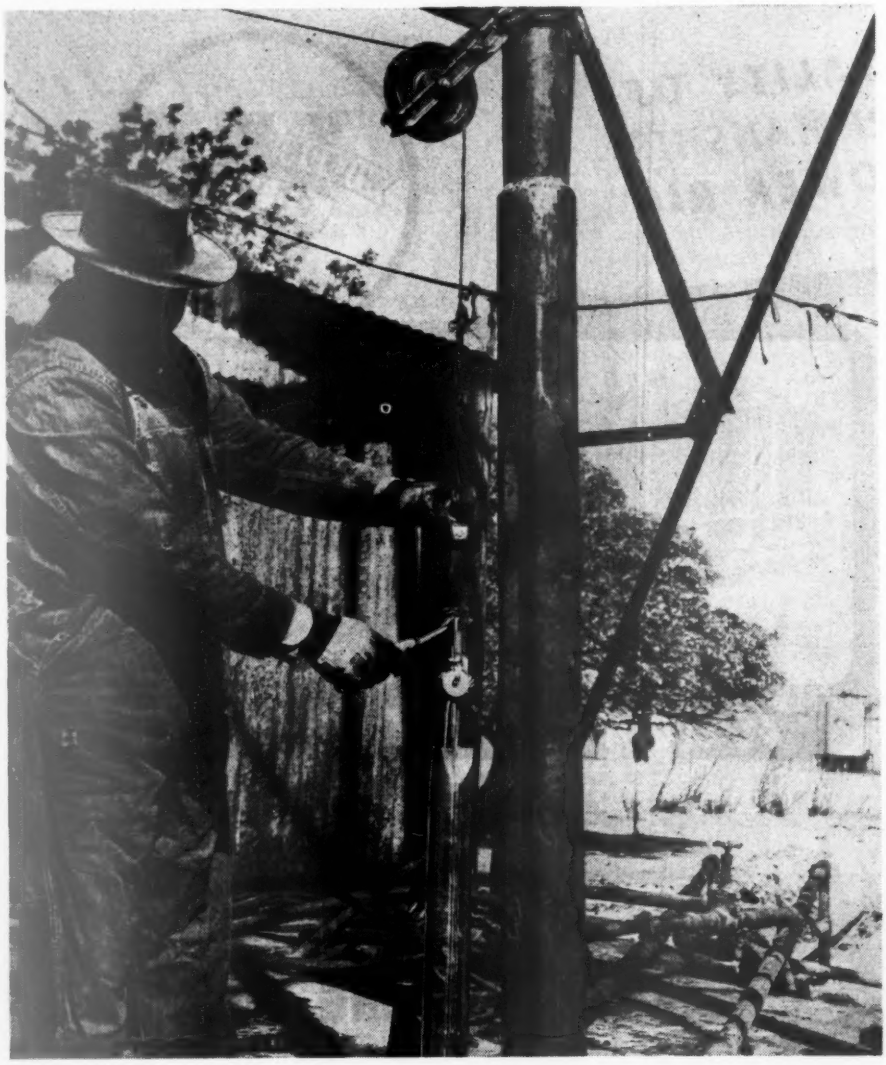
free the congestion entirely, but most newly drilled wells must be cleaned by some method other than swabbing and bailing.

Large shots, even though confined, do not always increase the size of the well bore as much as is sometimes believed. The increase is thought to be about double the diameter of the drilled hole, such as from a 6-in. drill hole to a 12-in. shot hole. The earth's weight and pressure is often so much in a hole fully loaded and tamped that the explosive may only spring the walls slightly. The only increase in size is accomplished by pulverizing an inch or so of the formation immediately opposite the explosive, and shattering additional formation to an inch or so in depth. When this pulverized and shattered information is cleaned from the walls, the natural formation is exposed. Some of these observations were made by measuring test holes drilled in edges of canyons and quarries where it was possible to remove the overburden to reveal the portion of hole shot; others were made by measuring the quantity of chat necessary to fill each linear foot in oil well shot holes and by running caliper logs.

● **Shot holes are small.** Cleaning congestion caused from drilling and producing, thus restoring the true formation, is the primary problem in producing wells profitably. This congestion is a natural reaction and is to be expected when rupturing nature's true formation. It is fortunate that shoe holes are small, for when a well becomes clogged in producing, the congestion is local to the well bore and accessible for retreatment. By considering the number of feet of pay section in connection with daily production, it is realized that the daily production usually travels through much more formation than is accessible to treatment by shooting. In view of the distance that production must necessarily travel before ultimate recovery during a period of months and years, it is apparent that the formation immediately surrounding the well bore is primarily a conduit agent. Little additional production can usually be gained by making a large shot hole. Nature takes care of the production until depletion, if the bore of the well is freed from congestion caused by drilling and periodically cleaned.

● **Key to effectiveness.** An unconfined explosive will probably neither spring nor clean the walls of a well effectively. It is accepted practice in mining to use explosives only in fully loaded holes, but it has not always been applied to oil well reconditioning. The usual shot containers are much smaller in diameter than the bore hole, and give a negligible amount of resistance to the explosive. The containers naturally tend to erupt in the direction of least resistance. Therefore, the congested formation is seldom pulverized and shattered enough to free the walls, and the usual shooting treatment may have little more than a brushing effect. The energy of the explosive may be dissipated by plunging into any breaks, and by-passing irregularities in reaching for the largest cavities in which to expand. Confinement tends to retain all the force of an explosive, but force alone does not necessarily obtain the maximum productivity of oil and gas in many formations. Each well should be considered individually and scientifically to determine the degree of force necessary to obtain the best results from the explosive used. There is need for more study in the use of explosives in treating wells.

When the entire length of torpedo to be run is loaded and weight suspended from single conventional pulley, the tie on hook, which would foul the release of torpedo, is removed.



● **Marbles confine the explosive.** To clean congested wells, an explosive should be uniformly deployed. Marbles placed around explosive seem to deploy the explosive's energies uniformly. In using small columns of explosive alone for cleaning congested wells, the results often may be damaging, for the concussion can more tightly seal the formation.

● **Design of the marble shot.** The marble torpedo is designed to give a uniform pattern of hits. Each linear foot of annulus contains 242 marbles. Six marbles rest against each marble. Each of the seven marbles have one point of contact with the explosive container and with each marble adjacent to it. Upon detonation the explosive container disintegrates between the contact points of the marbles to the explosive container for there is less resistance in these areas than at the points of contact. The six openings around each marble create six cones of reflection giving practically positive alignment and a uniform pattern of hits. This makes the explosive container of the torpedo a new and effective tool, inasmuch as some of the energy of the explosion is directed with practical uniformity through the gaps opened between the marbles as through a number of jets.

● **Action of marbles.** Experiments show that the instantaneous heat occurring at detonation of nitroglycerin is 6280°F., however, the momentary delay of the marbles to begin moving at high velocity after the explosive container disintegrates is insufficient to burn or damage the marbles. When laced tightly against the explosive container, experience has indicated that the explosion will not break, crack, burn, or harm glass marbles, and they reach and penetrate the formation whole.

It has been confirmed by surface experiments that, where marbles penetrated to great depth, the heat of penetration causes disintegration in the sand, but the depth of penetration in

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comparatively solid surfaces, such as producing formations, is seldom great enough to produce such heat. The marbles are usually stopped after relatively shallow penetration by the increasing resistance of the formation, and, when stopped, they disintegrate with a blasting force toward the center of the well bore in the form of powdered and shattered glass.

● **Advantages of small explosive column.** Each drop of explosive used adds greatly to the bulk strength, and the more used the greater the power. Knowledge obtained from the bulk strength of explosives has been applied for many years in shooting wells. The fundamental principle of the Agate torpedo is different inasmuch as it harnesses the power of the explosive and directs it against the wall of the hole by means of the marbles. The effectiveness of the tool is evidenced by the disintegration of the marbles, and it is believed the size of the tool is sufficient to clean adequately the largest shot holes.

The marble torpedo is being used safely and effectively, open and untamped, and in many cases within inches of both cemented and uncemented liners and casing shoes. It has been found practical to disregard oil levels in the casing, but water levels should be below the casing, if possible, before the torpedo is run.

The torpedo weighs only 4 lb. per ft. completely assembled and may be run in long columns with standard shooting equipment. Due to the advantages gained by having a fragile outside marble container, the tool is designed so that the explosive container carries the column weight. For safety in running and to obtain rigid columns, the entire length of torpedo is run in a basket. Sections are placed in position, loaded and lowered until the basket is filled, then the entire column is run directly from the shooter's reel. This eliminates the necessity of derrick lines and derricks in running columns long enough to cover entire pay sections. The average length of column run to date is 50 ft. and the maximum has been 200 ft.

● **Methods of running.** The torpedo is loaded with explosive, section by section, as it is lowered into the well. After determining the length of torpedo to be run, making necessary allowance for the method of detonation using squib wire, solid steel wire, or shooter's wire, according to the strength needed, a basket is constructed that will be long enough to contain the entire length of the shot. The basket wire is threaded through the equalizer on the bail and the ends of the wire fastened to the ears of the torpedo shoe.

The simplest method of running is that used when the 5-ft. sections are lowered into the well with a derrick line and hand snubbed every 5 ft. as the sections are loaded with explosive. When all sections have been loaded the bail is engaged in the shooter's hook and the derrick line is released.

Another method, and one that will fit all conditions at a well, is as follows: The shooter's truck is placed far enough from the hole to accommodate the entire length of the basket that is to contain the shot. The bail-equalizer is hooked into the shooter's hook and tied. The double line of the basket is run over a special double pulley and tied at least 5 ft. above the casinghead. This pulley must have openings on each side so that the lines can be disengaged. A change-over for conventional running is necessary. When the equalizer rests upon the division of the double pulley, adjustments are made by giving the line from the reel slack enough to thread over the shooter's conventional pulley. This must be tied at least 2 ft. above the double pulley. Then, re-roll reel tight by hand, lock, and the weight resting on the double pulley is lifted by pulling down on the shooter's line half way between the truck and the well. The double pulley is then completely disconnected leaving the direct weight on the conventional pulley. Care should be exercised to release the tie to insure natural action of the shooter's hook.

Secure the top of the bomb container or torpedo to the basket wire. Hand tighten the wires in the connecting sleeves to keep the wire basket in alignment, and place paper disks between sections when using liquid explosives to eliminate hazards. Best results are usually obtained by detonating the torpedo from the top. ★★★

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About half nation's natural gas reserve of 165 trillion cu. ft. is estimated to be situated in 19 fields.

REVIEW OF MAJOR U. S. GAS PRODUCING FIELDS

K. MARSHALL FAGIN, *Field Editor*

As this article is being written many of the nation's natural gas operators and conservation authorities are busy completing the preparation of information and testimony to be presented at the hearings of the Federal Power Commission to be held in Kansas City, New Orleans, and other places this fall. Very little detailed and up-to-date information about most of the natural gas fields is to be found in the usual literature. Much more complete information about all the natural gas producing fields is needed for a better understanding of the multitude of problems involved in properly regulating (not regimenting) the flow of gas from the earth to the consumer, and for the continued reduction of waste.

EXCLUSIVE

Disregarding the lack of sufficient details on the majority of the smaller gas fields and the questionable nature of some of the estimates of gas produced "from oil wells," the total natural gas reserve of the United States is roughly estimated to be about 165 trillion cu ft. (see Table A).

The 19 fields listed in Table 1 are credited with a total reserve of nearly 87 trillion cu. ft. or 52 per cent of the total for the nation. Almost one-half of this reserve is estimated to be in the two major fields of the country, the million and one-half acre Panhandle field of Texas and the three million acre Hugoton field to the north that stretches from Texas to Kansas.

● **Gas-condensate fields are numerous.** It is interesting to note that of the 19 fields in Table 1 most are classified as "gas-condensate" type fields, and that only a few of these are as large as 25,000 acres. These fields might be more properly termed "condensate-bearing gas" fields. Perhaps more than 250 fields of this type have been discovered so far, and many of these may ultimately produce as much as 1 to 3 trillion cu. ft. from relatively small areas, but much information must be obtained on reservoir size, depth, porosity, pressure, temperature and other factors before the gas reserve of these fields may be estimated individually with much reliability.

It should be added that in many of these gas-condensate fields only 1 to 4 wells have been completed, and that they are shut-in without markets for the gas or without cycling plants. Information on such fields is usually difficult to obtain.

● **Oil fields produce much gas,** Another interesting observation about Table 1 is the presence among major gas and gas-condensate fields of North Kettleman Hills, East Texas, and Seeligson. The gas produced at present from these fields is largely gas that comes out of solution as the oil is produced. This is especially true in the East Texas field where the average gas-oil ratio is only 350 cu. ft. per bbl. A little gas is produced from a small gas area near the south end of the field, however.

In the Seeligson and North Kettleman Hills fields, the average gas-oil ratios are much higher due to the presence of large gas caps in some of the oil sands and difficulty in completing low-ratio wells below the gas-oil contacts. Both of these fields have wells that will produce only gas, or gas and condensate, and a large gas reserve may be left unproduced until the oil wells are depleted.

Cycling of the gas in the gas cap could be performed to recover condensate in fields like these. The feasibility of cycling projects must be carefully considered in advance and permission obtained from regulatory authorities. Cycling must be controlled to prevent the possibility of the gas cap contracting, for this might cause the movement of oil into the dry gas sand of the cap and irreparable loss of some oil.

There are many oil fields, especially in Texas and Louisiana, that have large gas caps or separate gas-condensate reservoirs, but conservation rules usually limit or prohibit production of gas from the caps, and wells completed in gas-condensate reservoirs are sometimes kept shut-in for years while attention is concentrated on exploiting the oil reservoirs. In fields with multiple oil and gas-condensate reservoirs, many of the wells are dually-completed in an oil sand and a gas-condensate sand. The gas-condensate side of a dual well may be kept closed except to supply gas for drilling and lease needs.

In many cases, only one well in an entire field may be completed in a gas-condensate sand, all other wells being cased-off from the gas-condensate reservoir or reservoirs and being used solely to recover oil. For this reason, very little is ever widely known of the potential gas-condensate production. Gas reserve estimates based only on the production record and reservoir data of the one well might reflect only a trivial portion of the proved gas reserve.

● **The Hugoton field.** The tri-state Hugoton-Guymon natural gas field, the most extensive one in the world, stretches northward from Sherman and Hansford counties in Texas to Kearney and Finney County in Kansas. It is about 150 miles long and 35 miles wide and covers from 3 to possibly 4 million acres of gas producing territory. Only 350,000 acres, or about 10 per cent of the proved area, have been developed to the present time, but the 630 wells can deliver an estimated volume in excess of 1½ billion cu. ft. per day at an operating pressure of 310 lb.

Although the discovery well, Traders Oil Corporation No. 1 Boles, was begun in 1919 (in search of oil) it was not completed until December, 1922. It was situated a few miles west of Liberal in Seward County, Kansas, and drilled to a total depth of 2919 ft. by the middle of 1920. Gas showings were found between 2581 and 2755 ft., and the well was finally plugged back and completed with an initial open flow volume of about 8 million cu. ft. per day. The second well, Home Development Company No. 1 Allison, situated near the town of Texhoma in Texas County, Oklahoma, was completed the same year and supplied gas to local consumers for several years.

Development of the field was slow, largely as a result of drilling for oil. Lack of market and the depression impeded drilling, but 26 wells were completed in 1936 in addition to the 140 wells already drilled. The Texas portion of the field is only fractionally developed at the present time as indicated below:

Hugoton

State	No. Wells	Proved acres	Developed acres
Kansas	404	1,700,000	220,000
Oklahoma	182	900,000	110,000
Texas	44	400,000	20,000
Total	630	3,000,000	350,000

Estimates of the proved area range upward to almost 4 million acres. It is possible that even this figure may prove too low. Likewise, some gas reserve estimates are higher. Increased demand for gas from this field is stimulating drilling activity at the present time.

● **The Panhandle field of Texas.** Although rated here as the nation's second largest gas reserve, the Panhandle field still closely rivals the Hugoton field for first place. The 10.9 trillion cu. ft. it produced represents more than half the cumulative gas production of all the 19 fields listed in Table 1. and is more than 21 times the production from Hugoton. This past production easily puts

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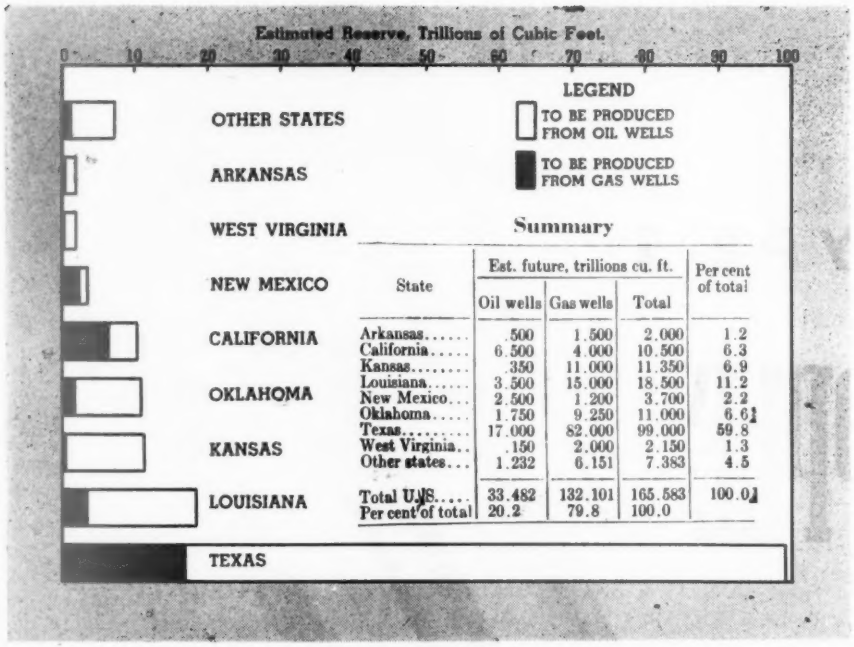

Summary

State	Est. future, trillions cu. ft.			Per cent of total
	Oil wells	Gas wells	Total	
Arkansas	.500	1.500	2.000	1.2
California	6.500	4.000	10.500	6.3
Kansas	.350	11.000	11.350	6.9
Louisiana	3.500	15.000	18.500	11.2
New Mexico	2.500	1.200	3.700	2.2
Oklahoma	1.750	9.250	11.000	6.6
Texas	17.000	82.000	99.000	59.8
West Virginia	.150	2.000	2.150	1.3
Other states	1.232	6.151	7.383	4.5
Total U.S.	33.482	132.101	165.583	100.0
Per cent of total	20.2	79.8	100.0	

FIG. 1. Estimated natural gas reserves of the U. S. by states and by sources.

it into first place in the ultimate column with 30 trillion cu. ft.

The rate of production in December, 1944, more than 900 billion per year, is nearly 9 times the rate of production from Hugoton, and indicates a much shorter life due to practically complete development of the 1,500,000 acres in the field with 1650 gas and 5880 oil wells. The field extends from the Shamrock area in Wheeler county on the east to Hartley County on the west, a distance of about 130 miles.

Sweet natural gas is produced from the East field containing about 275,000 acres and from the West field covering approximately 820,000 acres. Sour gas is produced from about 365,000 acres. Gas from the oil wells (casinghead gas) is included in the production figures and reserve estimate. A breakdown of daily average production for December, 1944, is as follows:

Panhandle

Type of gas	Millions cu. ft. per day
Sweet	1,680
Sour	658
Casinghead	156
Total	2,494

Although the field may be extended somewhat by future drilling, little activity is anticipated. Estimates of the gas reserve range from 17 to 22 trillion cu. ft. at the present time. Approximately one-half of the present production is shipped through pipe lines. One-third (mostly sour gas) is used for the manufacture of carbon black, and the remainder is used for plant and lease fuel or returned to the producing formation. Less than 1 per cent is lost by venting to the air.

● **The Katy gas-condensate field.** Katy, the third largest gas field in the United States, is situated in Waller County about 25 miles west of Houston in the Texas Gulf Coast area. With one well to a section, and with nothing but wellhead connections visible, the only evidences of activity in the area are the busy tank car loading platform along the railroad and the cycling plant towering above the prairie about a mile north of the road to Houston.

The field was discovered in 1935 and development was very slow the first few years due to the lack of a market for the gas production. Operations were unitized about 1940, however, for the purpose of building the cycling plant to strip the condensate from the gas and return the residue to the producing formation.

Here, as in most of the present gas-condensate fields, the gas reserve may not be available for pipe line delivery until the cycling process has run its course (in one of the separate reservoir sands at least), for a reduction in reservoir pressure caused by failure to inject the residue or stripped gas would usually result in the loss of part of the condensate by condensation in the reservoir sands, according to the accepted theory. This underground loss would be reflected by the decline in reservoir pressure and a more rapid decline in condensate yield per volume of gas processed through the plant, and the plant would serve merely to strip the gas produced as in a gasoline plant.

The cycling process at Katy is reflected by the small cumulative gas production figure. A few oil wells have been completed on the north part of the large dome-shaped structure.

● **The Old Ocean gas-condensate field.** Old Ocean, the fourth largest gas field in the nation, is situated in Brazoria County about 40 miles south and west of Houston, Texas, near the town of Sweeny. Many wells have been dually-completed at several levels from 9200 to 11,000 ft., and as a result the well-spacing in each of the several separate reservoirs is not the same as the surface spacing, which ranges from one well to 40 acres to one to 160 acres.

Oil is produced from many of the wells situated low enough on the dome-shaped structure. Gas-condensate is produced from most of the reservoirs over the top of the structure. Some of the gas is marketed, but most of it is returned to the reservoirs after it is processed by the gasoline plant.

● **The Carthage gas field.** Much attention has been focused on the Carthage field of Panola County, Texas, during 1944 and 1945 due to the large extensions given to the proved area by several new wells plus the consistently high initial open flow test measurements recorded. The majority of the wells are dually completed. New gasoline plants and pipe line outlets are under construction to strip the gas of condensate and supply the anticipated market demand for gas from this eastern Texas area.

● **Agua Dulce - Stratton.** The Agua Dulce - Stratton field is situated in Nueces, Jim Wells, and Kleburg counties, Texas, about 25 miles southwest of Corpus Christi in the lower Texas Gulf Coast area. Its estimated gas reserve in Table 1 puts it in sixth place among the U. S. gas fields. The bulk of the gas produced from this field has been returned to the reservoirs after being processed through 5 or 6 cycling plants. Of 138 billion cu. ft. produced from 128 gas wells during 1943, 105 billion cu. ft. was injected.

● **Rio Vista and Seeligson.** The Rio Vista gas field of Sacramento and Solano counties, California, is shown in seventh place in size among the gas fields of the nation. It has provided a much needed gas supply to the West Coast during the war and partially offset the diminishing reserve, which is largely from oil wells.

The Seeligson field of Jim Wells County, Texas, is an oil and gas-condensate type of field with many separate reservoir sands. It holds the nation's eighth largest gas reserve according to the estimate in Table 1, but this should be considered only as a preliminary rat-

TABLE A. Estimates of natural gas reserves.

	Billions of cu. ft.		
	From oil wells	From gas wells	Total
Arkansas	500	1,500	2,000
California	6,500	4,000	10,500
Colorado	20	100	220
Illinois	300	10	310
Indiana	15	10	25
Kansas	350	11,000	11,350
Kentucky	100	1,000	1,100
Louisiana	3,500	15,000	18,500
Michigan	20	180	200
Mississippi	100	1,100	1,200
Missouri	..	1	1
Montana	30	1,000	1,030
New Mexico	2,500	1,200	3,700
New York	2	100	102
Ohio	50	950	1,000
Oklahoma	1,750	9,250	11,000
Pennsylvania	45	1,000	1,045
Texas	17,000	82,000	99,000
West Virginia	150	2,000	2,150
Wyoming	550	500	1,050
Other states*	..	100	100
Total	33,482	132,101	165,583

*Other states include Alabama, Florida, Nebraska, North Dakota, South Dakota, Tennessee, Utah, Virginia, and Washington.

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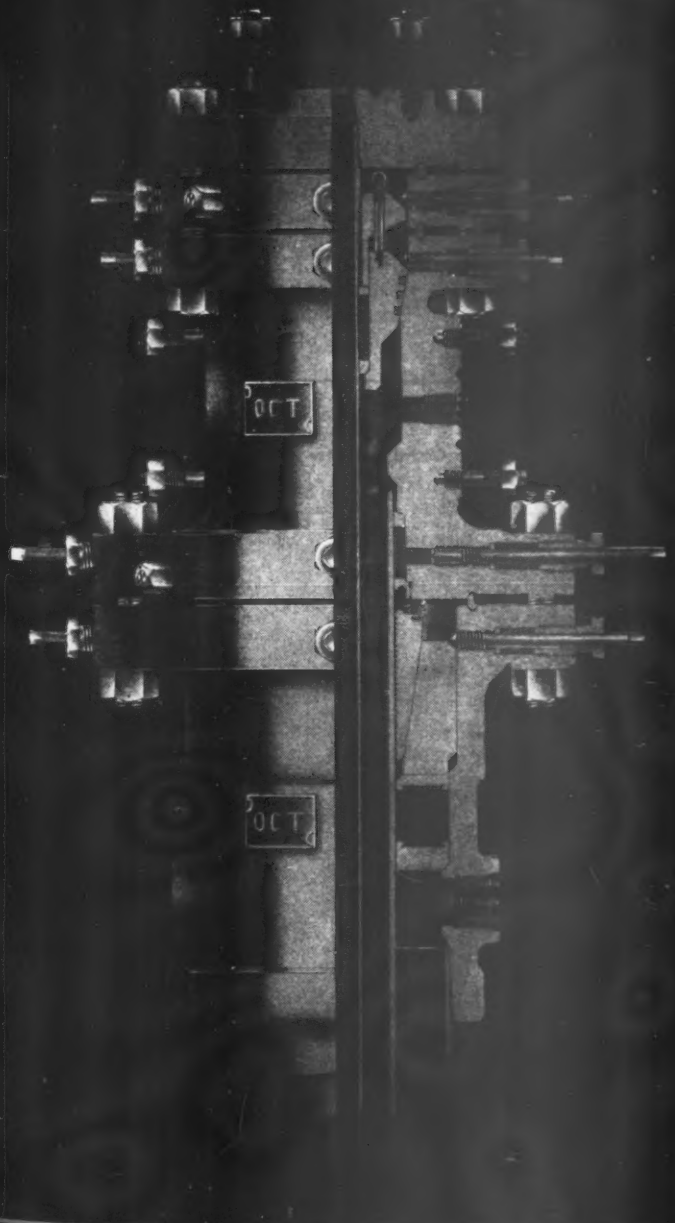

The O-C-T improved well head assembly pictured at left strikes a new note in high efficiency. It consists of an O-C-T Type "C-9" full opening, slip-suspension Casing Head with Hycar packing assembly molded to hinged junk rings, split slip bowl and three segment slips, above which is flanged an O-C-T Type "T-16-I" Tubing Head with a Type "S-2" Attachment.

Note that not a single API ring gasket is exposed to pressure, consequently those vital rings are not subject to failure due to corrosion or erosion. The dangers of defective metal ring gaskets, and leaky ring gaskets due to "stretched" flange studs, etc., are also eliminated.

One of the most important features of this well head assembly is the lack of welded seals which, under the most favorable conditions, are frequently unsafe. The efficiency of the oil-resistant Hycar seals has been proven under test pressures ranging up to 15,000 lbs.

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ing. Most of the sands will produce gas and condensate from the crest of the structure and oil from the flanks. Some of the 8 or 10 gas wells drilled thus far are dually completed in oil sands. These wells have been kept closed for the most part except when taking care of peak demands for drilling and lease fuel.

● **Sheridan.** A tentative figure of 2 trillion cu. ft. places the Sheridan field of Colorado County, Texas, in the ninth reserve position among the country's major gas fields. This field is situated southwest of the Katy field and about 60 miles west of Houston in the Texas Gulf Coast. Unlike Katy, which produces from Yegua sand of Eocene age, Sheridan produces from several separate reservoirs in the older Wilcox sands of Eocene age.

Full development of these reservoirs probably will be slow due to their number and to the need for either a market for the gas or more probably the unitization of the leaseholds in the field and a cycling plant. Like Katy, however, oil is produced from some of the sands on one of the flanks of the structure. Some preliminary estimates indicate both a greater producing area and net sand thickness than shown in Table 1.

● **La Gloria and Erath.** Closely rivaling the Sheridian field, the La Gloria field of Jim Wells and Brooks counties, Texas, holds the tenth gas reserve position in the nation. The field is situated southwest of Corpus Christi and south of the Seeligson field. Most of the 30 producing wells in the field are dually completed and yield gas from two of the four main Frio-Vicksburg sands of Oligocene age. The field is unitized and a cycling plant returns to the reservoirs nearly 90 per cent of the gas produced. Approximately 72,373 million cu. ft. was injected in 1943 out of 75,518 million cu. ft. produced from the wells and processed for condensate production by the plant. This practice, as at Katy, is reflected in the low cumulative production shown in Table 1. Oil is being produced from a few wells on the flank of the faulted anticlinal structure.

The Erath gas-condensate field of Vermilion Parish, Louisiana, is credited in Table 1 with the eleventh largest gas reserve in the United States. The field is about midway between Lake Charles and New Orleans in the Louisiana Gulf Coast. Unitization of the wells and leaseholds was climaxed by the installation of a cycling plant during 1944.

Production of gas is obtained from a large number of Upper Miocene sands that blanket the dome. As at La Gloria and Katy, the bulk of the residue gas is returned to the formation to maintain the reservoir pressure and prevent underground loss of condensate by condensation in the sands. One or two wells on the flank of the structure produce crude oil.

● **Paradis and Monroe.** The Paradis field is situated in St. Charles Parish about 20 miles southwest of New Orleans in the Louisiana Gulf Coast area. It tentatively holds twelfth place in the reserve column but this estimate like many others, especially those under 3 trillion, is subject to appreciable change in the light of more study and better information. Paradis is primarily an oil producing field at the present time, but it contains gas-condensate sands. Some wells have been dually completed in these Upper Miocene sands that are found on the crest of some of the fault blocks of the dome-shaped structure. Plans have been studied to construct a cycling plant.

The Monroe gas field is situated in northeast Louisiana and extends over portions of Morehouse, Ouachita, and Union parishes. Approximately 74 per cent of the estimated ultimate recoverable dry gas has been produced since the field was discovered in 1916, but the estimated remaining reserve of 1.3 trillion cu. ft. is enough to place it in thirteenth place among the nation's leading fields from the gas reserve standpoint. Furthermore, it is in second place in 1944 production. Its production rate may be passed soon, however, by both Hugoton and Carthage.

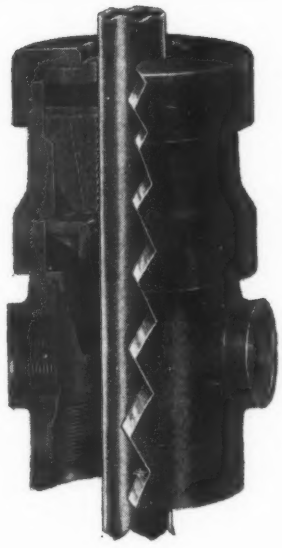
● **North Kettleman and Logansport-Joaquin.** The North Kettleman field is situated in Kern and Fresno counties in the San Joaquin Valley area of California. Although primarily an oil field, approximately 100 of the 280 wells in the field are classified as gas wells. About 80 billion cu. ft. of gas was produced during 1944 from both gas wells and oil wells to put it on a par in fifth place with the Charleston field of West Virginia in the matter of present production. The reserve estimate in Table 1 is based primarily on general information and on the rate of gas production. More pertinent reservoir information and further study may reveal an appreciably greater gas reserve.

The Logansport-Joaquin field is situated in DeSoto Parish, Louisiana, and Shelby County, Texas. Like other bi-state and twin-state fields its size frequently goes unnoticed except when shown on a regional map. In this case, however, few people would know that this one field has a different name in the two states.

The field has been very slowly developed since its discovery in Texas in 1931 due to a lack of market demand. It was not extended into Louisiana until 1938 although two-thirds of the proved area is now in that state. The wells are drilled on production units ranging from 160 to 1280 acres in size, and very little condensate is stripped from the volume of gas marketed. It is one of

TABLE 1. Data and estimates of the large natural gas producing fields of the United States.

State	County	Field	Date of discovery	No. of wells	Avg. depth ft.	Estimates as of Jan. 1, 1945			Estimated gas recovery—billions of cu. ft.			Estimated 1944 gas production, billions of cu. ft.	Type of field
						Proved area, acres	Oil and gas thickness, ft.	Ultimate recovery per acre, M. cu. ft.	Cumulative to Jan. 1, 1945	Future as of Jan. 1, 1945	Total ultimate		
Arkansas	Columbia	Dorcheat-Macedonia	1941	90	8,400	5,000	90	166,667	80	920	1,000	35	Gas-condensate and oil.
California	Kern and Fresno	Kettleman, North	1928	280	9,500	16,000	800	187,500	1,740	1,260	3,000	80	Oil and gas.
	Sacramento & Solano	Rio Vista	1936	70	4,000	25,000	120	120,000	370	2,630	3,000	130	Dry gas.
Kansas, Oklahoma, Texas	Stevens and others, Texas, Hansford & Sherman	Hugoton	1922	630	2,800	3,000,000	30	8,000	516	23,484	24,000	115	Dry gas.
Louisiana, Texas	DeSoto, Shelby	Logansport-Joaquin	1931	35	5,000	24,000	50	50,000	105	1,095	1,200	30	Dry gas.
Louisiana	Morehouse & others	Monroe	1916	1,350	2,200	250,000	40	20,000	3,700	1,300	5,000	225	Dry gas.
	St. Charles	Paradis	1939	65	9,500	5,000	150	300,000	10	1,490	1,500	4	Gas-condensate. and oil
	Vermilion	Erath	1940	45	9,000	3,000	250	500,000	6	1,494	1,500	2	Gas-condensate
	Webster	Cotton Valley	1922	150	8,000	12,500	60	80,000	385	615	1,000	65	Gas-condensate and oil.
Texas	Carson and others	Panhandle	1918	7,500	2,500	1,500,000	50	20,000	10,900	19,100	30,000	819	Dry gas & oil.
	Brazoria	Old Ocean	1934	130	10,500	12,500	250	500,000	440	5,810	6,250	50	Gas-condensate and oil.
	Cherokee and others	East Texas	1930	25,000	3,600	140,000	35	12,500	785	965	1,750	48	Oil and gas.
	Colorado	Sheridan	1940	6	10,000	5,000	200	400,000	3	1,997	2,000	1	Gas-condensate and oil.
	Jim Wells	La Gloria	1939	30	6,200	6,000	150	300,000	25	1,775	1,800	8	Gas-condensate and oil.
	Jim Wells	Seeligson	1937	300	6,000	15,000	200	150,000	20	2,230	2,250	15	Oil & gas-condensate.
	Nueces and others	Agua Dulce-Stratton	1928	320	6,500	25,000	150	200,000	200	4,800	5,000	45	Gas-condensate and oil
	Panola	Carthage	1936	60	6,000	200,000	30	25,000	50	4,950	5,000	22	Gas-condensate
	Waller	Katy	1938	30	7,000	25,000	200	400,000	100	9,900	10,000	30	Gas-condensate and oil.
W. Virginia	Jackson and others	Charleston		1,000	4,000	....	..	....	630	870	1,500	80	Dry gas.



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the deepest "dry" gas fields, and the wells are not so large as those in the Carthage field of Panola County immediately north of Shelby County. The Rodessa and Sligo formations of lower Cretaceous age contain the nominal gas reserve of about 1 trillion cu. ft. On the Texas side these formations are known as the upper and lower Glen Rose of lower Cretaceous age. The confusion created in the mind of an uninformed reader by the different names in the two states for both the field and the pay formations might be termed "the state line effect or complex."

● **East Texas and Dorcheat - Macedonia.** Although the East Texas field is an outstanding example of a low gas-oil ratio, water drive oil field, the large oil production yields nearly 50 billion cu. ft. of "wet" gas per year. The field has a gas reserve from the oil wells of nearly 1 trillion cu. ft., making it the sixtenth largest gas reserve in one field in the nation.

Gas production from an oil field like this is something that must be disposed of as the oil is produced. It often cannot feasibly be returned to the oil formation, because of divergent ownership of small leaseholds coupled with the practical impossibility of forming a field wide unit for pressure maintenance by injection of the residue gas. Fortunately, conservation of gas produced by oil wells in the East Texas field has been steadily improved since the early years of the field's life when the bulk of the gas was not even stripped of its natural gasoline content but burned in flares at the end of separator vent lines.

The Dorcheat-Macedonia gas-condensate field is situated in Columbia County, Arkansas, about 50 miles east of Texarkana. Oil was produced from many of the wells on the flanks of the anticlinal structure. Many of the wells are still classified as oil wells although the gas-oil ratios and the gravity of the crude have gradually increased in most of them to the point where little distinction for statistical purposes, at least, can be made between them and the gas-condensate wells higher on structure.

Macedonia was discovered in 1940 and Dorcheat in 1942. The structures were finally determined to be connected by a relatively narrow saddle. Most of the original wells were completed in the oolitic Reynolds lime of Jurassic age at a depth of about 8900 ft. Sour gas and condensate were produced from most of them. The sulphur is removed from the gas by a desulphurization plant. About 1942 several lenticular reservoirs in the Cotton Valley sands of the same age were proved for production of sweet gas and condensate at depths ranging from 7500 to 8100 ft. Several of the original wells were soon dually-completed in these shallower sands and some new wells were drilled.

Gas from the field has been used to help supply the demand created by the war plants situated in Arkansas. The average gas-condensate ratio was approximately 14,000 cu. ft. per bbl. from all reservoirs in 1944. The estimated gas reserve is nearly 1 trillion cu. ft. to place the field in seventeenth place among the fields in Table 1.

This gas reserve is almost as available as the gas reserve of an ordinary field, since pressure maintenance is not being practiced. Should there be a sharp curtailment of the demand for gas, production of condensate would have to be curtailed to prevent the necessity for venting gas to the air.

● **Charleston and Cotton Valley.** Perhaps several gas-condensate or even some oil and gas fields not shown in Table 1 will ultimately surpass the nominal reserve of 870 billion cu. ft. shown for Charleston, but this field, which is situated in Jackson, Kanawha, and Putnam counties in West Virginia, is given eighteenth place among the 19 leading fields listed largely because its 1944 production placed it in fifth place with North Kettleman in the matter of current rate of output. Charleston is also important due to its strategic location near the industries of the east. Further development may prove the purely nominal reserve estimate of less than one trillion cu. ft. to be too low, but the present wells may not produce as much as 500 billion cu. ft. in the future.

The Cotton Valley gas-condensate and oil field is unique in so many respects that its appearance in Table 1 as the smallest major gas reserve with only 615 billion cu. ft. was inevitable. There may be a dozen or more proved fields that will surpass this figure, but few have been operated with more pioneering and engineering than Cotton Valley since cyling was begun.

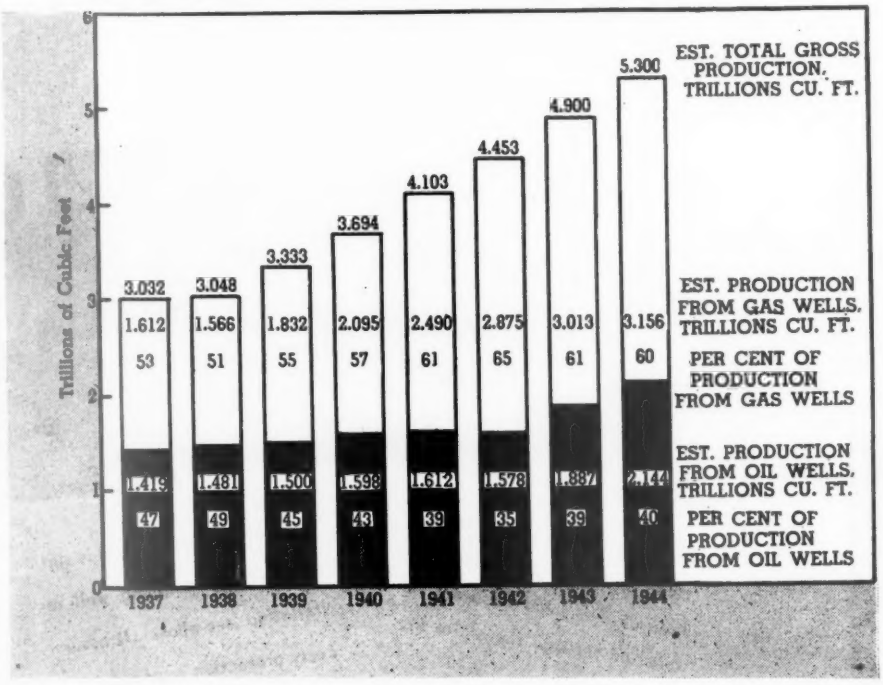
The field is situated on an almost perfect textbook type of domal anticline about 30 miles northeast of Shreveport in Webster parish, Louisiana. Shallow gas and some oil production was discovered in 1922 at a depth of 2560 ft. in the Buckrange sand of upper Cretaceous age. Glen Rose gas was discovered in 1926 at 4669 ft. Most of these shallow wells were exhausted by August 25, 1936, when the Ohio Oil Company completed a Holloway sand oil well at 5552 ft. Initial production was 480 bbl. of 51-deg. API gravity oil and 5 million cu. ft. of gas.

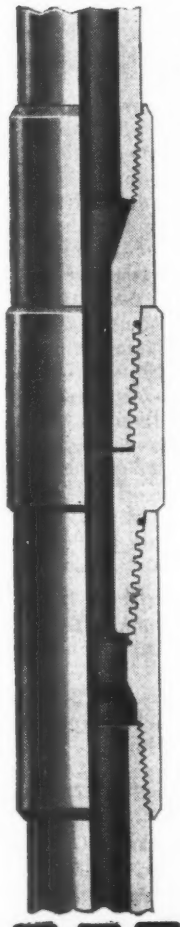
● **Deep gas sands discovered.** Search for still deeper production on the dome was rewarded near the end of 1936 by the discovery of rich condensate-bearing gas production from the Bodcaw sand at 8100 ft. in the Cotton Valley formation of Jurassic age. The initial gas-oil ratio was about 10,000 cu. ft. of gas per bbl of 62-deg. API gravity water white oil. Rock pressure was somewhat above 3000 lb. Development of the field to the Bodcaw and "D" sands progressed steadily with a well being drilled on almost every 80 acre tract on the producing part of the structure. A few oil wells were completed on the flanks of the structure on 40-acre tracts.

The wells were allotted fairly high allowables as deep "oil" wells, and the gas not used for fuel or marketed was flared. Fortunately, the deep rights in the field were unitized for construction and operation of a cycling plant shortly after the bulk of the development was finished. The deep oil wells on the rim were brought into the unit from month to month as their gas-oil ratios increased to the level of the gas-condensate ratios.

● **Cycling plant erected.** The cycling plant was built in time to supply many components needed for aviation gasoline and TNT for the war. Much of the gas from the Bodcaw sand reservoir has been produced, stripped of condensate, and the residue returned to the formation. Unusually detailed records have

FIG. 2. Estimated total gross production of natural gas in the U. S. for the years from 1937 to 1944 by sources.
(Estimates taken from "Minerals Yearbooks" of the U. S. Department of the Interior except for 1943 and 1944, which are estimated by the author.)





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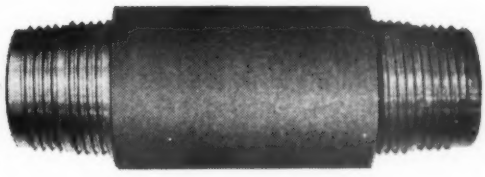

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TABLE 2. Estimates of natural gas production and average gas-oil ratio from oil wells—by states.

State	Cumulative (1859 to Jan. 1, 1945)			Reserves as of Jan. 1, 1945		
	Estimated total from oil wells		Average GOR, cu. ft. per bbl.	Estimated future production from oil wells		Average GOR, cu. ft. per bbl.
	Gas, million cu. ft.	Oil, thousand bbl.†		Gas, million cu. ft.	Oil, thousand bbl.‡	
Arkansas	600,000	616,407	973	500,000	293,059	1706
California	10,000,000	6,644,672	1505	6,500,000	3,344,552	1943
Colorado	8,000	49,555	161	20,000	88,823	225
Illinois	800,000	1,097,766	729	300,000	320,714	935
Indiana	50,000	155,597	321	15,000	31,493	476
Kansas	1,200,000	1,506,989	796	350,000	601,751	582
Kentucky	200,000	193,960	1031	100,000	41,080	2434
Louisiana	1,900,000	1,544,674	1230	3,500,000	1,573,387	2225
Michigan	35,000	222,497	157	20,000	65,134	307
Mississippi	8,300	83,874	99	100,000	209,011	478
Montana	20,000	115,538	173	30,000	111,650	269
New Mexico	1,200,000	423,843	2831	2,500,000	562,564	4444
New York	10,000	139,142	72	2,000	85,831	23
Ohio	600,000	601,722	997	50,000	31,624	1581
Oklahoma	6,600,000	5,349,317	1234	1,750,000	970,262	1804
Pennsylvania	400,000	1,061,494	377	45,000	123,138	365
Texas	9,200,000	8,910,246	1033	17,000,000	11,375,480	1494
West Virginia	1,500,000	424,196	3536	150,000	40,755	3680
Wyoming	500,000	629,455	794	550,000	581,730	945
Other states*	700	5,842	120	100	1,193	84
Total	34,832,000	29,776,786	1170	33,482,100	20,453,231	1637

*Other states include Alabama, Florida, Missouri, Nebraska, Tennessee, and Utah.
†From "Minerals Yearbook 1943" plus author's estimate for 1944.
‡Estimate made by the A.P.I. Committee on Reserves as of December 31, 1944.

been kept by the management for the unit operators committee. All gas production, reservoir pressures, movement of gas through the cycling plant, shrinkage loss and fuel used, and all other pertinent data on the complex operations have been recorded, summarized, analyzed, and elaborately reported to the original group of operators who formed the unit. Information on the experiences with a relatively new process such as cycling in a field apparently so well suited to it should prove valuable for future reference.

Retardation of reservoir pressure decline by cycling has tended to keep the gas-condensate ratio low. Dilution of produced gas by the injected residue gas has not been so serious a problem as it might be in some other more permeable reservoirs with less structural relief. Last year's net gas production of 65 billion cu. ft. from the field represents a peak demand for war that was met without upsetting the planned cycling program.

● **Classification of gas by source.** The brief discussion above of each one of the 19 leading fields shown in Table 1 illustrates the practical impossibility, often imposed by nature, of ever acquiring records by states, or even by fields in some cases, that will divide the gas "from gas wells" and the gas "from oil wells" with more than a faint degree of reliability.

The estimates of how much gas has been produced from each type of well are simply a matter of opinion. Unfortunately, for statistical and true conservation purposes, at least, there is a great diversity of opinion among oil and gas operators and governmental authorities regarding the definition of a gas well and an oil well.

In some states an oil well is an oil well until the last barrel of petroleum of either high or low gravity has been separated from the gas in a separator on the lease. The gas-petroleum ratio may be almost any figure above 100,000 cu. ft. per bbl. In other states, such as Texas, a well is reclassified as a gas well as soon as the ratio reaches that figure.

The problem of estimation is further complicated, however, by attempts to distinguish between crude oil and condensate, the latter being in a gaseous form in the reservoir.

● **Approximate classification of fields.** For purposes of comparison with Fig. 1, which purports to make a distinction by source, all fields shown in Table 1 may be classified as gas field except North Kettleman, East Texas, and Seeligson, which are predominantly oil fields. This division indicates 82 trillion cu. ft. will be produced "from gas wells" in these 19 large gas fields.

Of the 132 trillion cu. ft. total estimated reserve "from gas wells" in the nation (per summary in Fig. 1), an 82 trillion cu. ft. reserve or 62 per cent. is situated in 16 gas fields. More than 4 trillion cu. ft., or 13 per cent of the 33 trillion cu. ft. total U. S. reserve "from oil wells" is situated in 3 oil fields. Again, it should be stated that this or any other such division is necessarily arbitrary. Dorcheat - Macedonia, Paradis, Old Ocean, and Agua Dulce-Stratton are all recognized as important oil fields yet they are placed in the gas field column so far as the above division by source is concerned.

● **Effect of depth on gas reserve.** Calculations indicate it would take about 5 times as much gas sand at a depth of 2000 ft. to contain the same gas reserve as at a depth of 12,000 to 20,000 ft. In other words, 1 acre-ft. of gas sand in the deep range is equal to 5 acre-ft. of similar gas sand at a depth of 2000 ft.

This is important in more than one respect for many of the deep gas-condensate fields contain greater aggregate thicknesses of gas sand than the larger shallow gas fields. A small deep gas field with thick sands may be of much greater importance than a much larger shallow gas field with a relatively thin sand section.

Only a rather small difference exists in the gas reserve of an acre-foot of sand between 12,000 and 20,000 ft. This is due primarily to the effect of increasingly higher reservoir temperatures, and to the reversal of the effect of "deviation" from Boyle's view.

● **Records of U. S. gas production.** The increasing importance of natural gas to the nation is reflected in Fig. 2, which shows the growth of the total production year by year since 1937. The increase in production was stimulated to a considerable extent by the need for fuel and carbon black in the war effort, but the demand for natural gas is expected to continue at a high level as new uses for it are found.

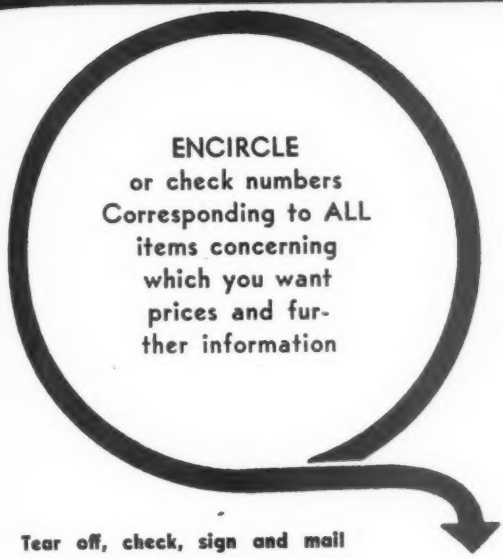
It is interesting to note that 40 per cent of the total gas produced was "from oil wells." Table 2 shows nominal estimates of the gas that may have been produced from all oil fields in the nation in the past and gas reserves from the same sources.

In general, the gas-oil ratios in the various states are now much higher than they were since the beginning due to the increased depth of many of the newer oil fields.

It should be emphasized that the estimates of the cumulative gas from oil wells is purely nominal. A great deal of laborious study might be expected to reveal appreciable differences. On the other hand, although the estimate of the future production is purely nominal, the records for the last 8 years were used as a guide and the estimate as a whole may be considered conservative.

In fact, the total proved gas reserve of the United States from all wells may be reasonably considered to be approximately 200 trillion cu. ft., but detailed estimates of the reserve in a thousand or so of the smaller gas fields, gas-condensate fields, and oil fields have not been made except by a few, and the records of gas production by fields are very incomplete in many areas of the nation.

● **Bibliography.** *AIME Petroleum Division Yearbooks;* the *National Oil Scouts and Landmen's Association Yearbooks;* the *Minerals Yearbooks* published by the U.S. Bureau of Mines; Jack K. Baumel's paper on "Natural Gas in Texas" that was presented to the Interstate Compact Commission meeting June 15, 1945; E. G. Dahlgren's article on "Hugoton" in the May, 1945, issue of the magazine GAS published at Los Angeles; Dr. E. DeGolyer's article on "Natural Gas Reserves" in the July, 1945, issue of GAS; Dr. George H. Fancher's article on "The Natural Gas Industry of Texas" in Vol. 1 of "Texas Looks Ahead" published by the University of Texas at Austin, and innumerable other articles and papers dealing with the subject. Further information on the Carthage and Hugoton fields and on the subject of conservation of the nation's reserves may be found in the June and August, 1945, issues of The Petroleum Engineer. ★ ★ ★



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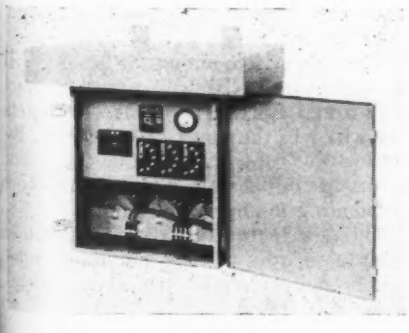
(1) *Rectifiers*

Cathodic protection rectifiers, designed to reduce to a minimum the galvanic corrosion of underground metal structures, have been developed by Federal Telephone and Radio Corporation, Newark, New Jersey, associate of International Telephone and Telegraph Corporation.

Buried structures, such as metal tanks, pipe lines, well casings, lead-sheathed cables, conduits, and similar installations are subject to chemical action between the metal and materials in the surrounding soil, capable of producing an electric current at the surface of the metal and causing galvanic corrosion, which will ultimately result in the destruction of the metal. Federal cathodic protection rectifiers counteract this current flow by introducing a potential between the structure and the soil in a direction opposing the galvanic current flow. To accomplish this, the Federal selenium rectifier contained in the unit converts standard alternating current power to continuous direct current power.

The federal cathodic protection rectifier, designated FTR-5114-S, operates over long periods without attention because of its lack of moving parts, its effectiveness over wide temperature ranges, its small standby losses, and immunity to injury from momentary high overloads, the manufacturer states. Reliability of the unit is further enhanced by the exclusive "center contact" method of construction of its Federal selenium rectifier.



Suitable for installation indoors or out, either on a wall or pole, the Federal cathodic protection rectifier is contained in a weather-proof sheet-metal cabinet with drip-proof hood and hinged cover affording easy access to the control panel. Taps and links permit ready adjustment of the d-c. output, which is indicated by an ammeter mounted on the control panel.

Designed for operation on 230-volt, 60-cycle, 3-phase power lines, to provide d-c. outputs up to 20 amp., from 10 to 40 volts, continuous duty, the complete unit weighs 150 lb., and is 23 in. high by 25⅝ in. wide by 19¼ in. deep.

Information on other sizes of Federal cathodic protection rectifiers, and copies of the FTR technical information reprint, "Cathodic Protection and Applications of Selenium Rectifiers" by W. F. Bonner, are available.

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(2) *V-belt lathe*

Latest addition to the South Bend Lathe Works' line is a V-belt drive 9-in. precision bench lathe, which is illustrated and described for the first time in Catalog 9-G, just off the press.

Made especially for those who prefer the several advantages of the V-belt drive, this bench lathe features 4-step, V-belt cone pulleys that, with the back gears, provide either 8 or 16 spindle speeds ranging from 46 to 1176 r.p.m. It is made with either quick-change gear or plain change gear equipment for a

wide range of thread cutting and power longitudinal feeds. Two of the models incorporate power cross-feeds.

All models have a 9¼-in. swing over the bed and saddle wings, and ¾-in. headstock spindle hole with maximum collet capacity of ½ in. Choice of bed lengths give maximum distances between centers up to 43 in. The usual line of South Bend attachments is available for special classes of work.

This lathe is ideal for precision toolroom or production work, and for general use in machine, laboratory, and repair shops for machining metals, plastics, compositions, and other machinable materials, the manufacturer asserts.

(3) *Clark "Big Angle"*

Clark Bros. 2-cycle "Big Angle" (BA--17) doubles the power previously developed by right angle gas engine driven compressors, the manufacturer states. Built in 3 different sizes—5 cylinder, 6 cylinder, and 8 cylinder, the BA-17 has a b.hp. rating of 1000, 1200, and 1600, respectively. With a 17-in. bore and 18-in. stroke, this new Clark production supplies that "additional power-per unit" required by the modern trend in pipe line practice, chemical processes, and refinery techniques, it is pointed out.

Considering the power developed, the BA-17 is surprising in the simplicity and compactness of its design. In fact, the absence of unnecessary, unsightly mechanical trappings on the exterior is a feature apparent at the first glance.

This simplicity of appearance and operation is reflected on the interior as well. Simplified design has been rigorously applied to the entire structure.

For instance, the power cylinders being nearly square and set close together with no overhanging projections, makes it next to impossible for dirt to collect in inaccessible locations.

Immediately below the face of the power cylinders comes the camshaft housing consisting of a series of removable plates. These, when removed, immediately expose the camshaft and cam followers for easy maintenance inspection.

The camshaft is operated by a chain drive from the crankshaft. The magneto or distributor, the governor, and the lubricator are driven by a separate chain drive. Both chain drives are situated at the flywheel end of the engine. This design prevents the possibility of any impulses emanating from the camshaft being transmitted to the auxiliaries.

The scavenging air manifold being cast into the upper crankcase creates a more adequate cross-sectional area and elminates unsightly air passages from the surface of the engine. By the device of casting a trough into the mounting flange of the lower crankcase, spilled lubricating oil is prevented from seeping into the grouting, thus assuring greater permanency of the engine foundation.

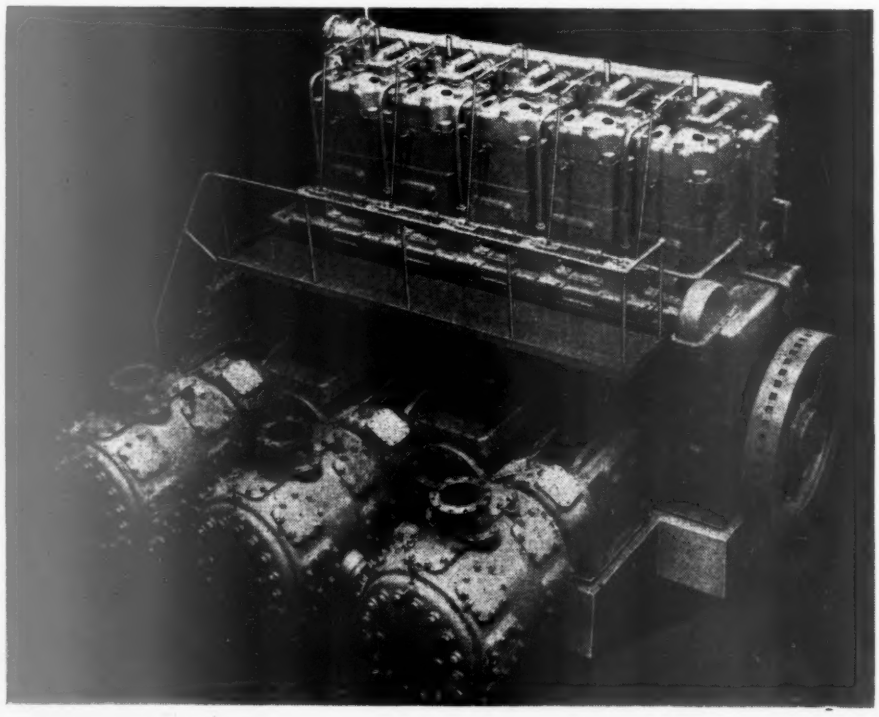
Power pistons are of three-piece construction. The piston head and ring carrier are made of steel for high temperature heat resistance. This steel construction reduces ring groove wear and allows the well finned head to be of minimum thickness for the best heat transfer to the oil cooled interior. The piston skirt is a symmetrical cylinder having no openings or bosses in it, this preventing uneven expansion. The piston fin is held in a carrier that forms the third part of the piston. The three parts comprising the complete piston assembly are united by heavy studs that pass through the pin carrier and piston skirt into the piston head.

Efficient cooling throughout is maintained by the improved high velocity water jacketing of the dry joint cylinder heads and the exhaust manifold.

For ease of operation, centralized control has been achieved by grouping the air starting lever, the fuel gas valve, the governor and the exhaust pyrometers all at one station.

The following are the principal specifications:

Model	No. of cylinders	B.hp.	R.p.m.	Overall length
BA-5	5	1000	300	17 ft. 6¾ in.
BA-6	6	1200	300	21 ft. 6¾ in.
BA-8	8	1600	300	25 ft. 6¾ in.



(4) *Electrode holder*

A new armor-clad (screw type), fully insulated electrode holder has been announced by the Electric Welding Division of the General Electric Company. Designed from the operator's viewpoint the new holder is recommended for use wherever durability, maximum safety, and minimum operator fatigue are desired, the manufacturer states.

A feature of the new holder is its head, which is completely enclosed in a sheath of aluminum armor. This armor protects the insulation, resists weld spatter, and eliminates the possibility of accidental contact with the welding circuit. Thus the holder remains clean while in use and lasts considerably longer than insulated holders without armor cladding, it is stated.

Designed to accommodate electrodes up to and including ¼ in. in diam., the holder is easy to use, light in weight (15 oz.), and unusually cool in operation. A slight twist of the hand tightens or releases the electrode. While in use, the holder firmly grips the electrode at the proper angle and good current contact is maintained. This keeps the holder cool, tends to prevent overheating of the electrode, and maintains a uniform melting rate down to a stub end. The threads of the push-up rod do not carry current. A soldered cable connection also helps the holder to remain cool. The width of the electrode slot limits the size of the electrode that can be inserted, thus preventing overloading, one of the evils that materially shortens the life of electrode holders.

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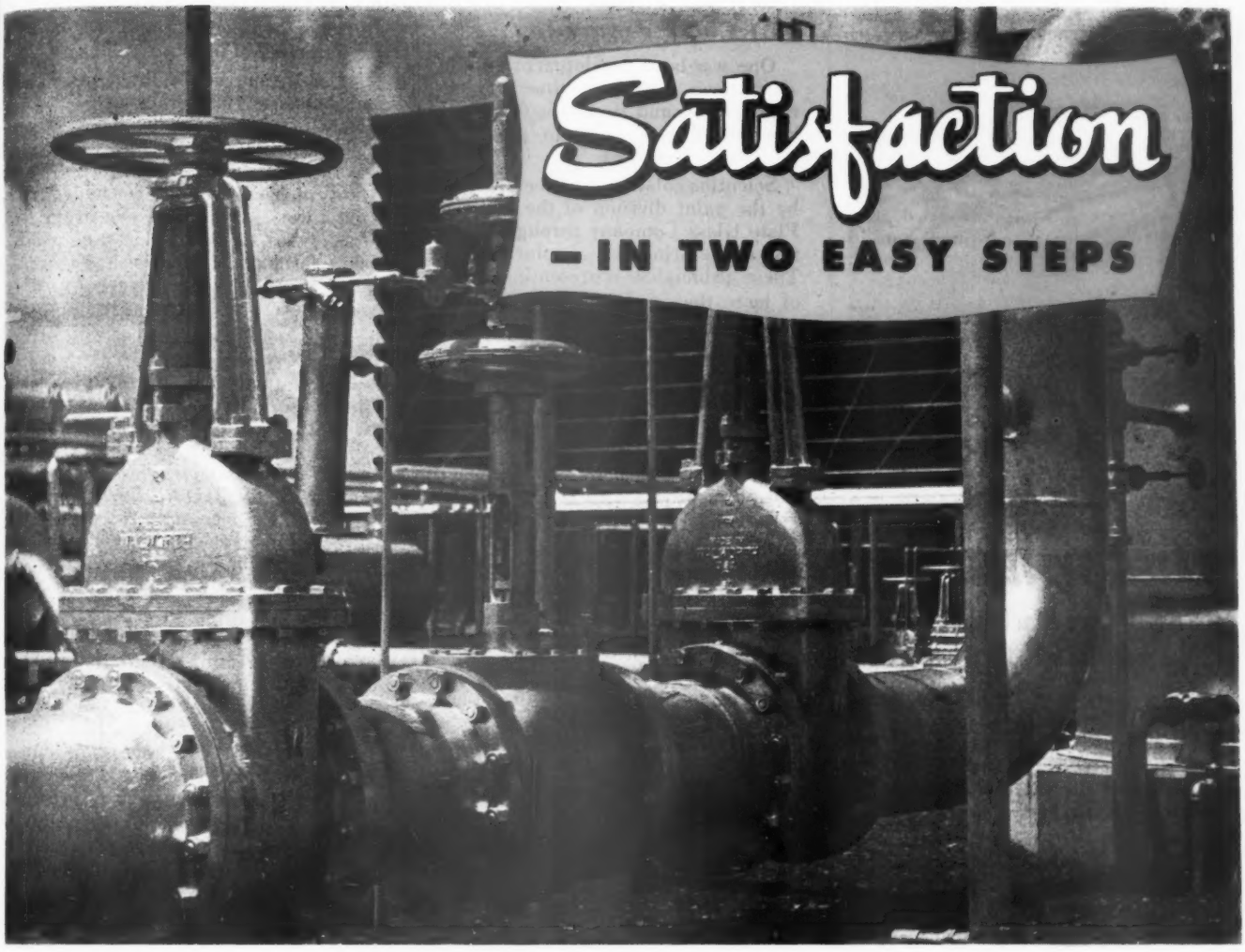
(5) *Chart drive control*

A chart drive control, embodying means for automatically starting and stopping electronic recorder chart motion by pen position, has been made available by the Brown Instrument Company, Philadelphia industrial instrument division of Minneapolis-Honeywell Regulator Company.

The chart drive cut-out, it is said, will be available for Brown's circular chart Electronik Recorder. Control contacts are wired in the chart drive circuit. By setting the control point the chart can be stopped and started as desired, corresponding to any pen position.

The new feature will find its greatest usefulness for molten metal thermocouple and radiation pyrometer applications, it is stated.



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(6) *Color dynamics*

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In the opening discussion of the industrial use of color, the 24-page, full color illustrated booklet *Color Dynamics In Industry*, is stated the three basic objectives of scientific color use.

These are: (1) To promote continuity of employment; (2) to improve efficiency of operation and, (3) to maintain quality of production.

Illustrating how color helps decrease absenteeism, reduce injuries, and promote better morale the booklet states: "The morale and efficiency of industrial workers are drastically affected by certain physical conditions under which they work. Continued eye-strain leads to nervous tension and causes unnecessary fatigue. Drab, cheerless surroundings encourages mental depression and makes every job seem much harder."

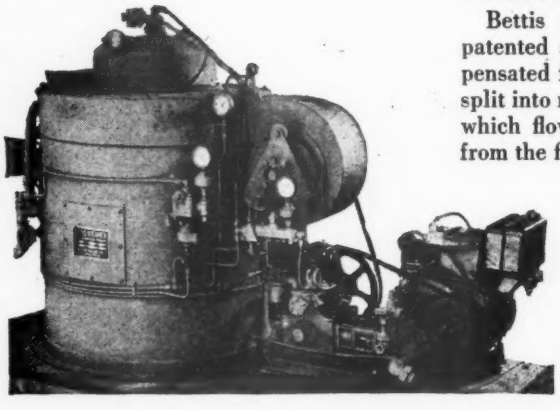
This booklet details how the color dynamics system eliminates many of these negative factors. It shows how color reduces the even more insidious "absenteeism on the job" in which a worker is continually finding reasons to leave his work. Color dynamics is concerned not only with the factory background but also with the machines. Suggestions are given on methods of painting machinery to reduce danger of personal injury, eyestrain, and physical and mental fatigue.

One of the highlights of the industrial color booklet is the section of 4 pages in color illustrating the progressive steps in transforming a dismal, gray factory building into a morale-building, efficient working area. The first illustration shows an example of the average shop finished in its dull gray. The second shows how painting the machinery in eye-rest and focal colors adds a note of brightness. In the next picture partial color painting of the floor and walls of the factory add efficiency, and the last picture shows what miraculous changes color can bring. Detailed discussion on choice and use of focal and eye-rest colors for various machines and shops is included in this booklet.

(7) *Portable steamer*

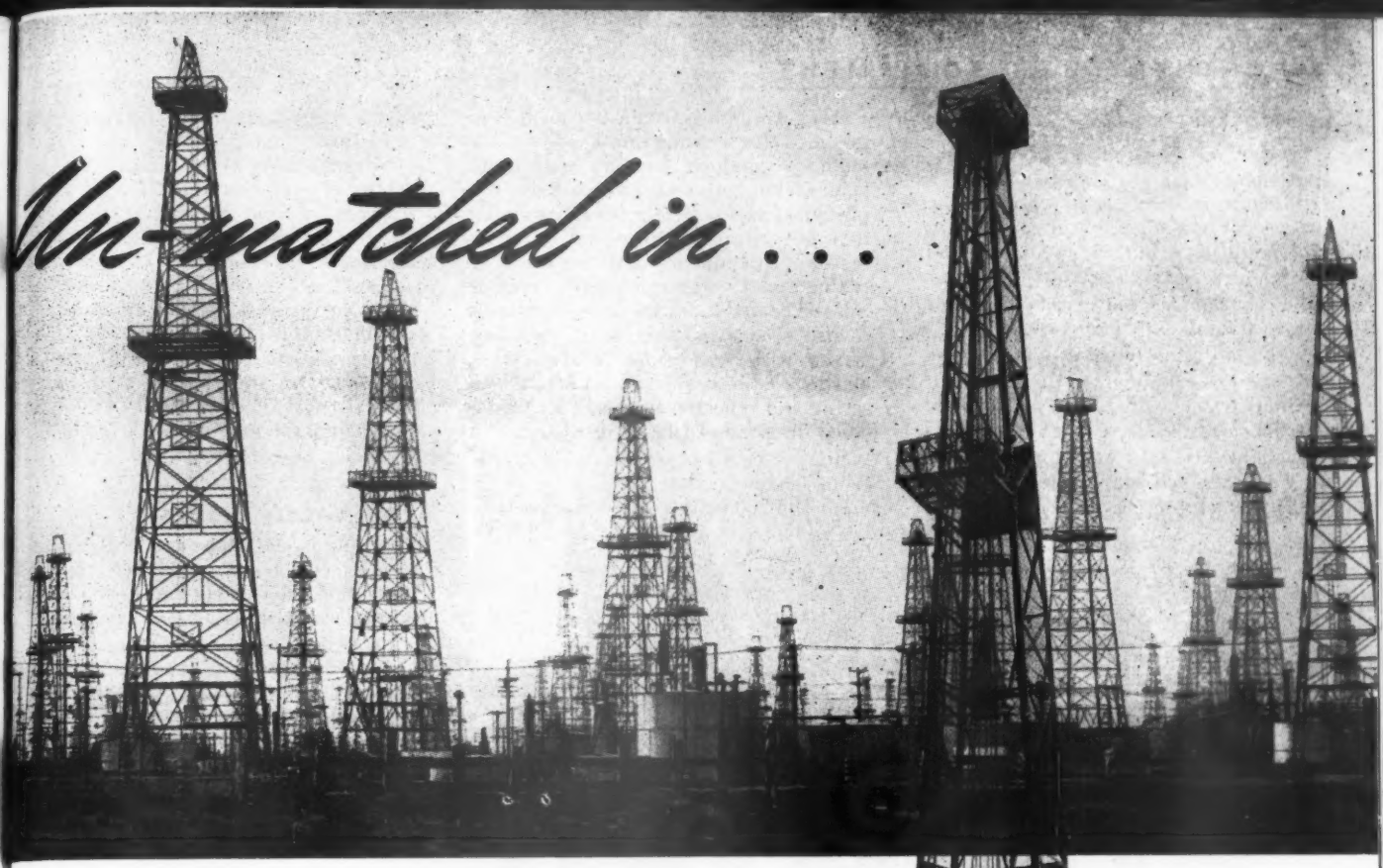
Bettis Sales Company, 1507 Maury Street, Houston, Texas, announces the addition of an improved 40-hp. unit to its line of Bettis portable steamers designed especially for oil field service. In addition to its adaptability wherever quick, portable steam is required, the 40-hp. steamer is particularly recommended for heating power rigs for winter-time operations.

The new unit supersedes the popular 30-hp. Bettis steamer and operates up to 600-lb. steam pressure. All-steel construction has been employed in the new unit to assure maximum strength with minimum weight. Other new or improved features include a new design triplex water pump combined with magneto and fuel pump that operates at the slow speed of 956 r.p.m., thus reducing wear and prolonging the life of this component. New and simplified controls make possible lower differential in cut-in and cut-out pressures. The unit operates on a 2½-hp. gasoline engine or 1½-hp. electric motor.



Bettis portable steamers employ a patented staggered coil assembly, compensated for expansion, and designed to split into narrow films combustion gases, which flow freely in opposite direction from the flow of water through the coils.

A single motor operates feed-water pump, fuel pump, magneto, and blower for combustion air. Thus, fuel supplied to burner is automatically regulated in relation to amount of water circulated and amount of air delivered for combustion.



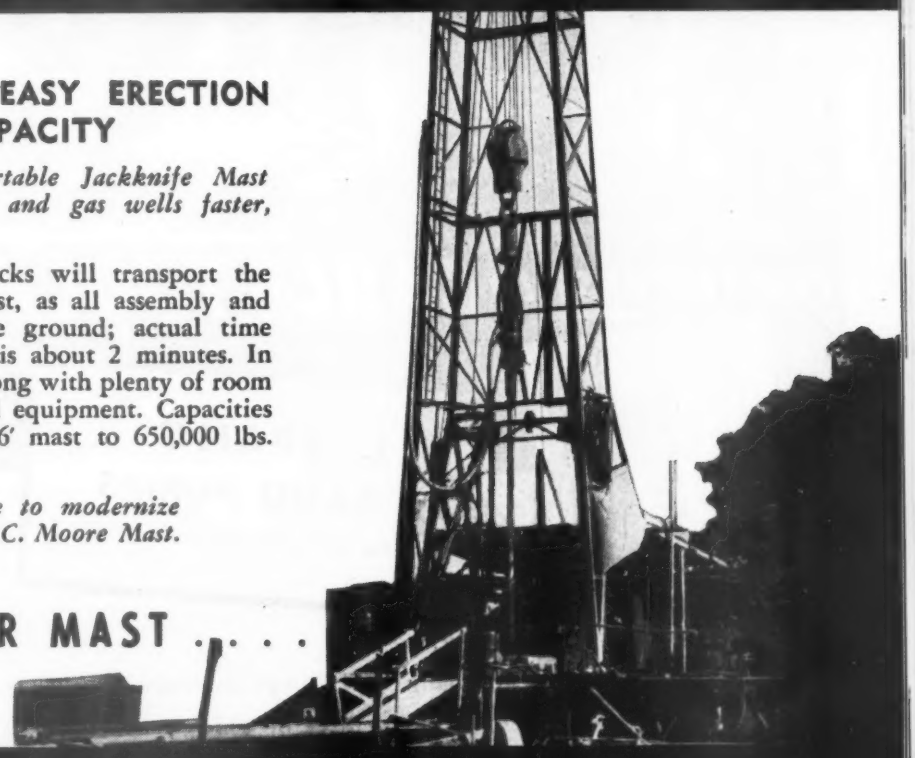
Un-matched in . . .

PORTABILITY ● EASY ERECTION OPERATION ● CAPACITY

The Lee C. Moore Portable Jackknife Mast makes the drilling of oil and gas wells faster, easier and safer.

Two or three trailer trucks will transport the largest mast. Erection is fast, as all assembly and rigging-up is done on the ground; actual time required to raise the mast is about 2 minutes. In operation, it's steady and strong with plenty of room on the derrick floor for all equipment. Capacities from 300,000 lbs. in the 86′ mast to 650,000 lbs. in the 136′ mast.

Now's a good time to modernize your rig with a Lee C. Moore Mast.



ACKKNIFE CANTILEVER MAST . . . .

LEE C. MOORE & COMPANY

INCORPORATED

PITTSBURGH ● TULSA

EXPORT: OILFIELD-INDUSTRIAL EXPORT, INC.

30 Rockefeller Plaza, New York 20, N. Y.

(8) *Silastic*

Dow Corning Corporation announces the commercial availability of Silastic, a silicone rubber, produced in various stocks for molding, extruding, coating, and laminating. Largely because of their inorganic origins, these rubbery organosilicon oxide polymers remain elastic after heating at temperatures up to 500°F. and retain flexibility at temperatures as low as minus 70°F.

Silastic stocks are available for molding flat sheets, gaskets, and other shapes. Silastic coated lead wire and other continuous extruded shapes are made from Silastic stocks designed for extruding.

Also available are Silastic stocks compounded for coating glass or asbestos cloth to produce flexible, waterproof, heat stable, oil resistant gaskets, diaphragms, tape and electrical insulation that is nontracking, arc and oxidation resistant. Laminates may be made by curing under pressure multiple layers of Silastic coated inorganic fabrics. Silastic is also used to insulate wire wound resistors with waterproof, heat-resistant, elastic coatings able to withstand the severe and repeated thermal shocks specified for Grade I Class I resistors.

Silastic coatings adhere to glass, vitreous enamel, iron, steel, and aluminum. They constitute protective coatings that are resistant to oil and salt brines at elevated temperatures.

Silastic stocks now available have exceptional temperature stability, tensile strength of from 200 to 330 lb. per sq. in., elongation ranging from 70 to 115 per cent, high resistance to water, brine, and oil, and electrical properties of the following magnitude: Dielectric constant at 1,000,000 cycles of 5.0 to 7.5; power factor at 1,000,000 cycles of 0.13 to 0.18 per cent, and dielectric strength of 500 volts per mil. The properties of Silastic stocks, notably their tensile strengths, are being steadily improved.

(9) *Nozzle tester*

A new model Universal diesel nozzle and injector tester, announced by The Buda Company of Harvey, Illinois, is a portable unit designed for use with all popular makes of diesel engines.

According to the manufacturer, no technical knowledge is required to operate the tester. Any mechanic or diesel engine operator can measure injector opening pressures with it, determine accurate adjustment, check spray pattern for uniformity, and detect other irregularities such as sticking needle valves, dribble and leakage around valve seats.

The Buda Universal diesel nozzle tester is equipped with a standard hydraulic pressure gage, 3-11/16-in. dial, 3000 lb. per sq. in. capacity, and 100-lb. gradations. Gages of 5000 and 7500 capacity are also available.

Completely portable, the tester weighs less than 19½ lb., including all-steel carrying case, one adapter, and removable 12-in. steel handle. The carrying case is 5⅝ in. by 7½ in. by 11½ in. and holds such extras as adapter fittings, special cradle, and "popping" device, extra pressure gages, risers, spray pan, high pressure lines, fittings, etc.

FOR THE BEST IN CABLE TOOLS

SPANG SAND PUMPS
(Fig. D393, Fig. D394, Fig. D395)

Spang Sand Pumps are made in a variety of styles, three of which are illustrated. They are made with either heavy-wall or light-wall tubes, and for any desired style of connection to the cable or sand line.

For the best in Cable Tools

SPECIFY SPANG

THE HIGHER STANDARD

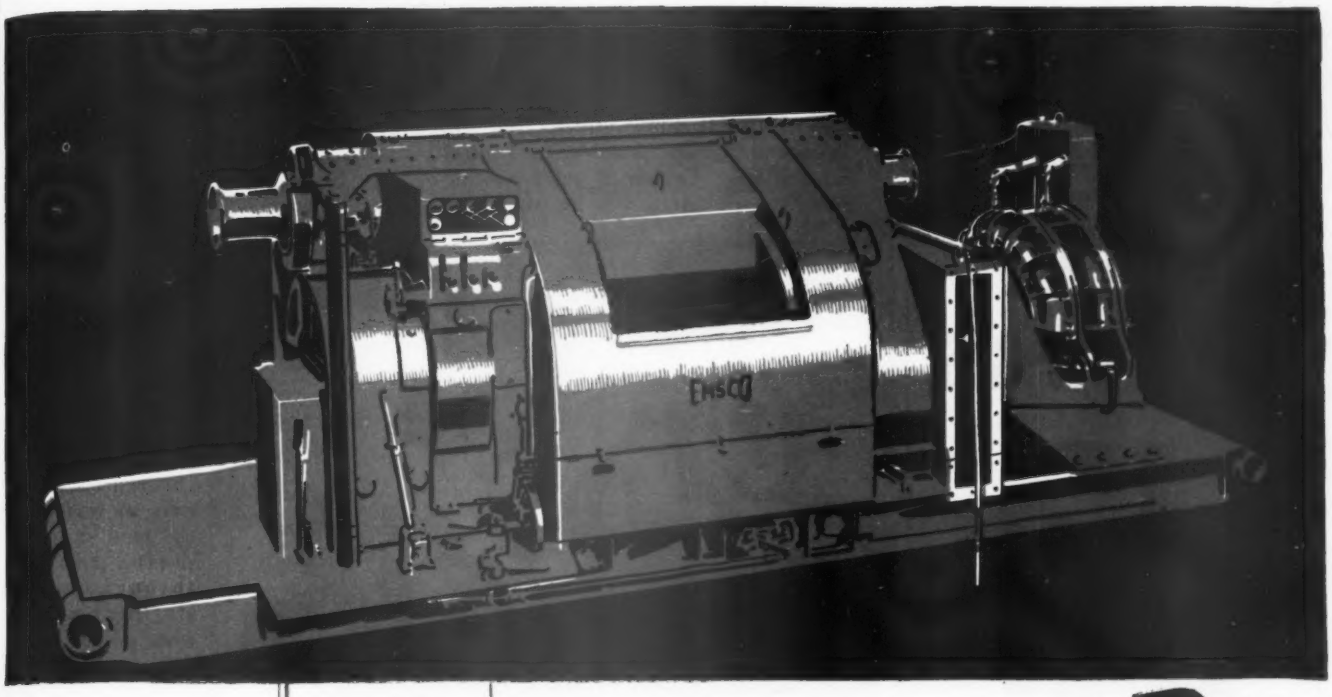
SPANG & CO.
BUTLER, PA.

YOUR DEALER SELLS SPANG TOOLS

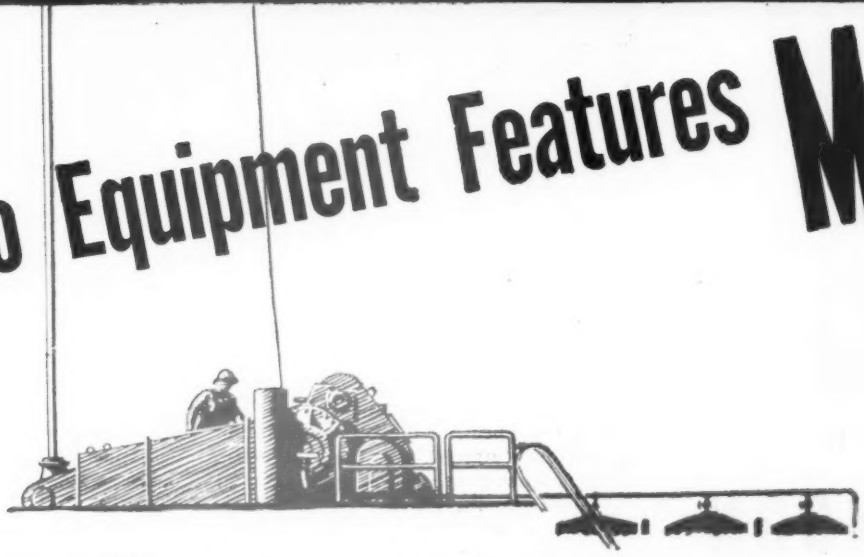
LUMBER FOR SALE

Oil field and Bridge lumber.
Hardwood Surveyor stakes.

E. J. GAIENNIE LUMBER CO.
Box 1074 Shreveport, Louisiana



Emsco Equipment Features M.D.*



HERE IS A DRILLER'S RIG!

Smooth dependable performance, fewer shutdowns, longer life . . . these are the characteristics built into every Emsco Draw Works. They have what we call Maximum Drillability, for they are designed to operate efficiently and economically under all drilling conditions. Consider the Emsco J-1250, for instance. It's a 1250 horsepower unit designed for the deepest drilling, yet has little increase in weight, and no sacrifice of safety factors over units of shallower depth ratings. It incorporates disc-type, air operated friction clutches, has 6 hoisting speeds, 3 rotary speeds, 2 reverse speeds to the drumshaft, and an outstanding brake design. This draw works meets road-width requirements without dismantling.

The complete rig consists of draw works, selective speed transmission, compounding transmission, engines and power slush pumps. The unit breaks down into convenient road-width packages. Careful attention to engineering details and the high quality of materials and workmanship provide a smooth, easily-handled, efficient drilling rig—the latest addition to the Emsco line.

ARMY-E-NAVY

DALLAS PLANT
HOUSTON PLANT

EMSCO

* MAXIMUM DRILLABILITY

EMSCO DERRICK & EQUIPMENT COMPANY

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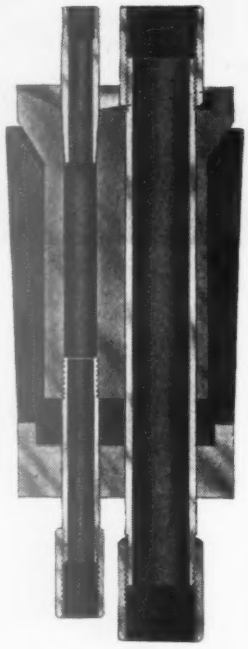
YOU CAN MINIMIZE LEAKY CASINGS



WITH

ROBINSON

RUBBER CUP PACKERS

For packing off water in wells from 500 to 2000 feet deep, this special Robinson product is both efficient and inexpensive.

WRITE FOR CATALOG FOR COMPLETE INFORMATION

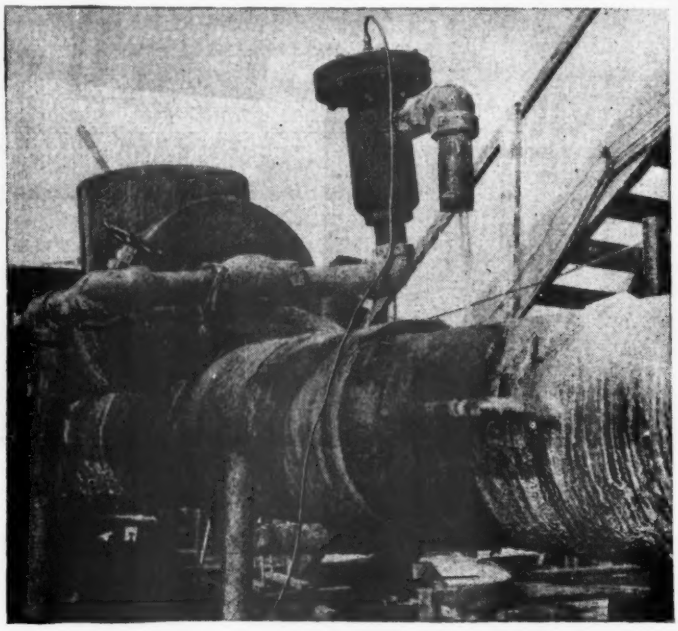
ROBINSON PACKER CO.

P. O. Box 1408
TULSA, OKLAHOMA

Factory: Coffeyville, Kansas

(10) *Water control valve*

Through the use of a new valve, introduced by Warren Automatic Tool Company, 1920 Hussion Street, Houston, Texas, it is now possible to control automatically the flow of water into the mud stream. Actuated by the mud pump, the valve allows water to flow into the stream only so long as the pump is running. As soon as the pump is shut down, the valve automatically stops the flow of water.



Constructed to deliver a full 2-in. stream of water, its output can be regulated to the exact volume necessary by the installation of a globe valve in the water line ahead of the valve. While the pump is running and the automatic valve is open the "derrick man" or mud engineer sets the globe valve to deliver the volume of water necessary to maintain proper mud weight and viscosity. When the pump shuts down this flow of water is stopped by the automatic closing of the valve.

This method of water regulation assures the operator better control of the mud weight and viscosity. It eliminates the necessity of adding additional weighting material due to failure to close the water valve while the pump is down. The automatic valve is especially valuable to the mud engineer or "tool pusher" when close control of weighted mud is necessary, because the regulated volume of water into the mud stream remains constant throughout each starting and stopping of the pump, the manufacturer points out. Should a damaged seat in the globe valve prevent complete closing, the automatic valve, by completely shutting off the flow of water, prevents such leakage from entering the mud stream when the pump is down.

The Warren Automatic Water Control Valve is actuated by steam pressure from the mud pumps, against a neoprene diaphragm that is spring loaded. All working parts in contact with the water are made of non-corrosive materials. The construction of the valve body and parts are rugged yet compact. Simple in design it gives maximum service with a minimum cost of maintenance, it is stated. The valve is 11 in. long and 9 in. across the top diaphragm plate. It weighs 39 lb.

(11) *Safety vents*

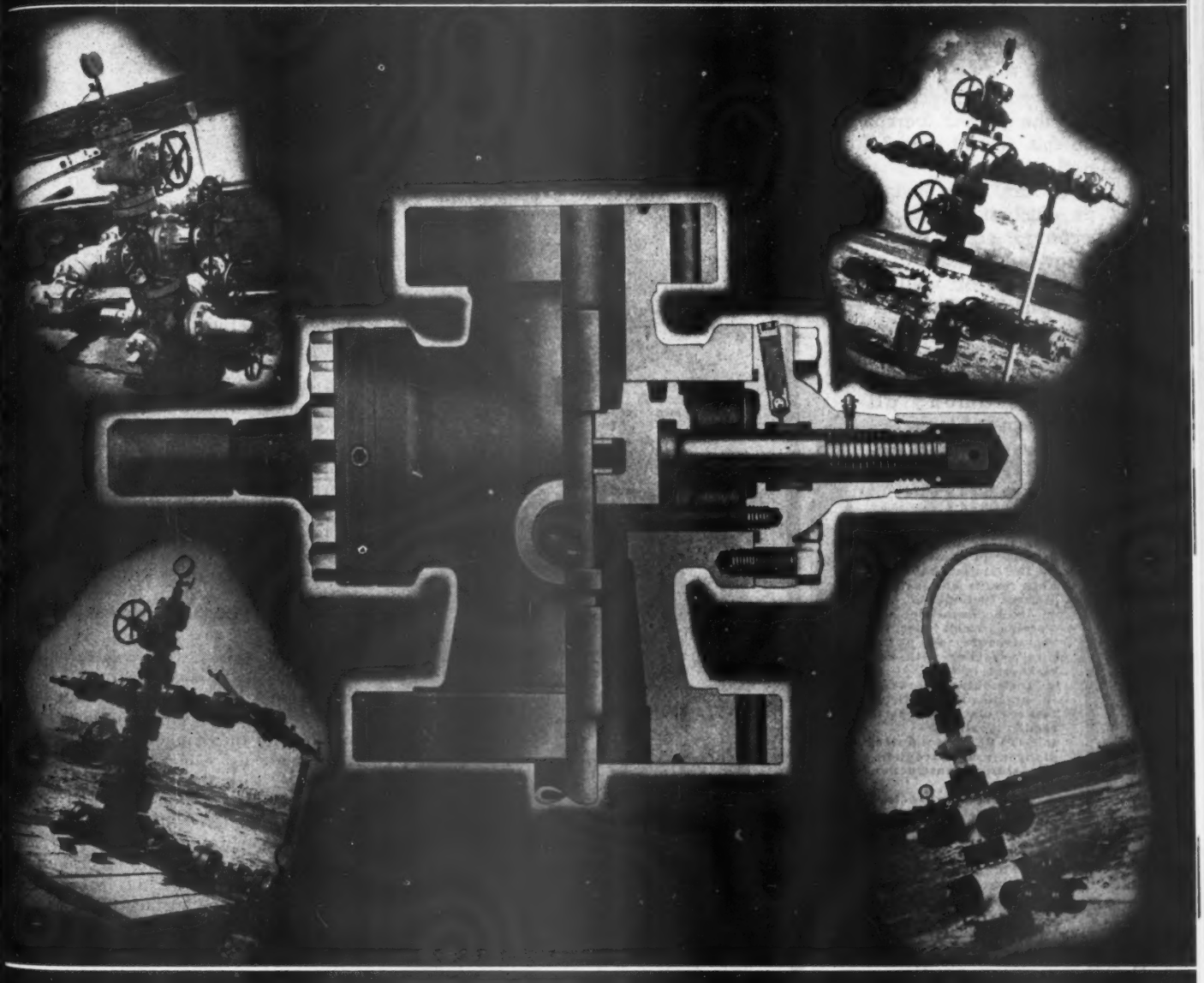
Safety vents with rupture diaphragm give a wide margin of protection against fire and explosion to tanks and processing vessels containing inflammable liquids. These units give double protection, in that they are a combination vapor valve and rupture diaphragm. They contain a special disk or rupture diaphragm that will break to relieve excessive pressures that build up within a storage tank. Thus, by permitting the escape of unusually high pressures, danger from explosions is reduced to a minimum, and human lives are protected and costly tank replacements are avoided.

In addition to the rupture diaphragm, these units have the ordinary function of permitting a safe escape of inflammable gases from a tank. This is accomplished by means of a specially designed unit with perforated brass flame barrier plates. Exhaustive tests have proved conclusively that this unique feature prevents flames from flashing back through the perforated vent plates into the tank where inflammable liquids might be ignited, the manufacturer asserts.

Safety vents are made in cast bronze, steel, semi-steel, or cast iron, with flange or butt-weld connections, in a wide range of sizes. They are manufactured by the J. A. Zurn Manufacturing Company, Erie, Pennsylvania.

The Safest Completions Are

CAMERON-IZED



CAMERON RAM TYPE TUBING CONTROL HEAD

Here is the tubing head that has distinguished itself as a vital unit in the widely accepted Cameron Closed Pressure Method of Well Completion, which method has demonstrated its high degree of safety and efficiency on hundreds of the world's deepest, highest pressure well completions. Its unique design, permitting the use of several interchangeable types of tubing suspension and seal (hanger nipple on closed rams illustrated), makes it equally outstanding in the field of equipment required for multi-zone completions.

The full opening vertical bore freely passes drilling-in tools, liner and screen, and packers. Its rams, provided with Cameron patented self-feeding packing elements, assure positive blowout protection while tubing is being run, well washed, packer collapsed, tubing suspended, etc. In fact, the highest pressure wells may be washed completely clean without danger of losing control during that critical stage.

Cameron ram-type tubing control heads, the foundation for Cameron Safety Xmas Trees and the Closed Pressure Method of well completions, are fully described in your Composite Catalog, a copy of which will gladly be sent to interested operators on request.

CAMERON IRON WORKS, INC.
711 MILBY ST., HOUSTON, TEXAS

Export: 74 Trinity Place, New York, N. Y. *California:* Howard Supply Co., Los Angeles. *Oklahoma:* 310 Thompson Bldg., Tulsa.

NOW I ASK YOU-

- Do you really believe I am the proper person to do this sort of work? I do not!
- In fact, I am just about as efficient at this as the average sand pump or clean-out bailer is at cleaning out an oil well.
- Confidentially, if you want a real clean-out tool go to your nearest supply store and order the tops among all clean-out tools . . .

"THE MIDCO BAILER"

- Every individual feature of the MIDCO contributes in some degree to the almost unbelievable results obtained.
- Large volume of sales in both Domestic and Foreign fields permits maintenance of price competitive with any clean-out tool.
- Distributors located in practically all fields make replacement parts readily available.
- G-TYPE has solid steel plunger rod—exceptionally sturdy construction throughout.

Standard cable tool pin permits Jars and Sinker to be run above pump, eliminating fishing jobs.

- F-5 TYPE has patented plunger construction to assure highest possible efficiency in this type of pump.

PATENT No. 2061486
2090055 — 2090209
2176231 — 2187642
Other Patents Pending

TYPE-G TYPE F-5

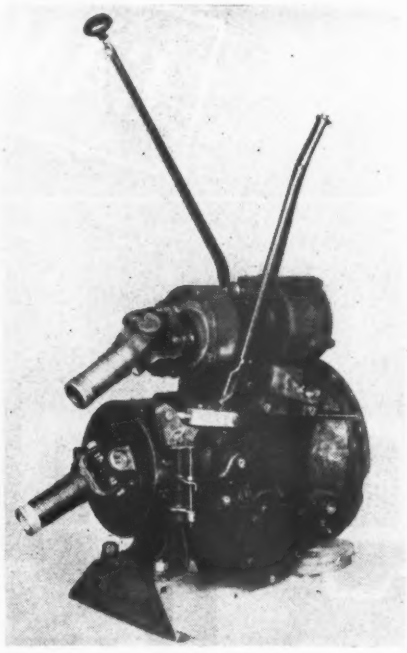
For additional information see COMPOSIT CATALOG, Page 1903
Call, wire or write

MIDCO BAILER CO.
1006 - 1012 S. E. 29th STREET
TELEPHONE 7-8586 BOX 1542
OKLAHOMA CITY • OKLAHOMA

(12) *Power take-off*

An idea in a power take-off direct-connected to a truck motor comprises one of the most compact set-ups of this kind and permits a convenient and efficient means for making readily available various power applications wherever they are required.

The accompanying views show one use for this portable power arrangement whereby it is used to drive the generator for an arc welding outfit supplied to The Lincoln Electric Company, Cleveland, Ohio.



New power take-off unit for truck motor.

One application of power take-off for driving welder generator mounted in truck body.

The power take-off, designed and built by A. Tangen, 3269 Hogarth, Detroit, Michigan, can quickly be installed in any Ford or Dodge truck as a permanent set-up, although it can easily be removed or reinstalled in a few minutes. Built as a unit, the driving mechanism fits directly over the standard transmission case of the truck and does not interfere in any way with the normal use of the truck.

This is said to be a very economical and convenient method for supplying generator power from the truck motor. Power is transmitted direct from the motor, thus the speed of the generator is the same as that of the motor. This has been found entirely satisfactory although the speeds could be varied if necessary under special gear ratios. The governor, which can be cut in or out quickly, is connected with the power take-off.

In the installation illustrated, the welder generator and supplemental equipment are compactly positioned in the truck immediately behind the cab.

The outfit is available as a kit with complete instructions for mounting, or it can be installed in the truck by the manufacturers.

---

(13) *Electrode*

A new type of cutting electrode, permitting greatly increased speed in metal cutting and for use at unlimited depths underwater, has been released by the Ellwood Products Corporation, Ellwood City, Pennsylvania. So designed that any unskilled workman can successfully cut metal after only 10 minutes instruction, the Ellpro electrode was developed primarily to permit salvage of damaged ships by the U. S. Navy, that are endangered by large masses of bent and twisted armor plate that prevent their proceeding to navy yards for repairs. By cutting away the extruding material the ships are able to return to harbor under their own power for complete overhauling.

The Ellpro electrode is made of steel in the form of a hollow tube with an adhesive-type coating that prevents it from sticking to the cutting surface. It is used with oxygen, which permits safety to the user at any depth underwater.

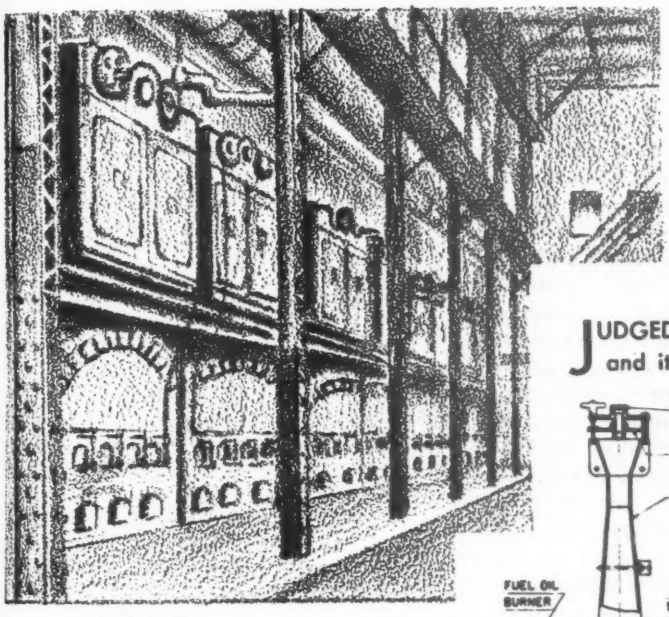
The adhesive coating was developed through cooperation, research, and exhaustive testing with the U. S. Naval Engineering Experiment Station at Annapolis and the Minnesota Mining and Manufacturing Company. The Ellpro electrode, with this coating, has been in production for some time and is the latest design offered for use in industry.

Speed of operation is a major advantage of the new Ellpro electrode. A molten arc is obtained the instant it is placed against the surface to be cut. It can be used successfully underwater or anywhere on land, with either a-c. or d-c. curent. A torch holder, perfected for use wtih the Ellpro electrode, prevents it from burning down to a point where it cannot be removed with ease. As its cutting life ends, it can simply be drawn from the holder and a new one inserted with practically no loss in time.

Although the electrode was designed primarily for underwater cutting, it is easily adapted to cutting scrap iron or steel, salvaging sunken marine equipment, and rehabilitation work in war-torn cities and towns.

1912 DOING "ONE THING" WELL 1945

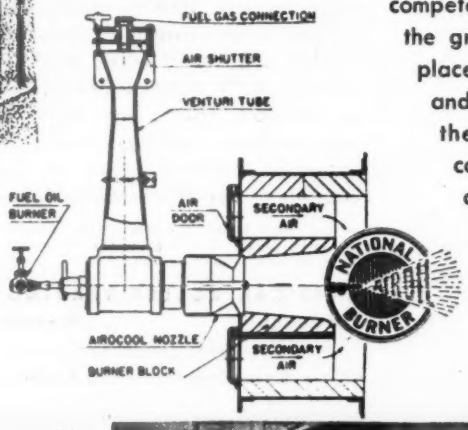
FOR 33 YEARS . . .



A 1910 Installation

NATIONAL AIROIL FUEL OIL - GAS BURNERS

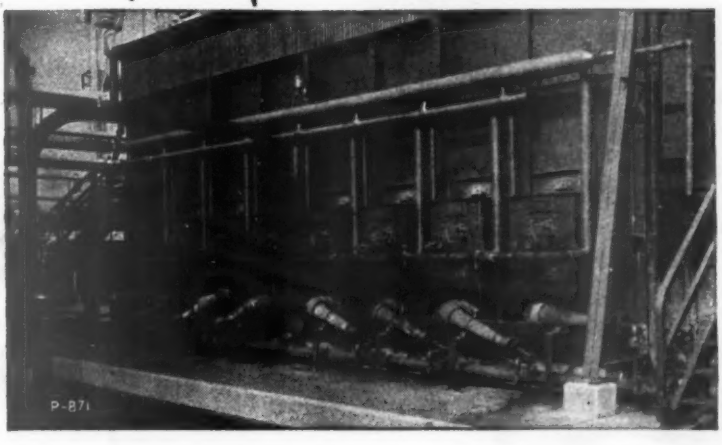
JUDGED by today's standards, this old furnace would be inefficient, and its oil burner—considered a good one in its day—couldn't compete with the burner of 1945. With the great changes that have taken place, not only in industrial demands and furnace designs, but also in the fuels themselves, it has become *essential* for the engineer and burner manufacturer to keep abreast of all new developments.



Because "combustion" is the very keystone of our business, we have, (for 33 years) through constant experimentation, research, and development-work, attained the enviable position of being able to offer *not only the proper burner or combination of burners for a given job,* but we can also *render unbiased, valuable, engineering advice.*

Today, our Tandem Block Oil Combination Units, fitted with the type burner the service indicates, are being widely used throughout industry, the world over.

A Modern 1945 Installation



NATIONAL AIROIL BURNER COMPANY, INCORPORATED
1259 East Sedgley Avenue
PHILADELPHIA 34, PENNA.

OIL BURNERS • GAS BURNERS • GAS PILOTS • PUMP SETS
• EXPLOSION DOORS • ACCESS DOORS • AIR DOORS
• BURNER BLOCKS • FURNACE OBSERVATION WINDOWS

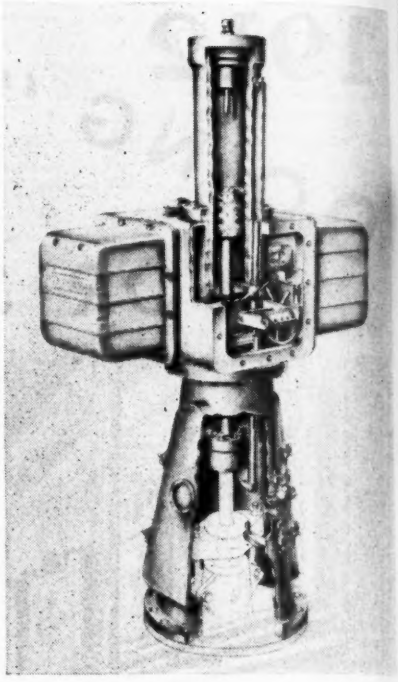
(14) *Bendix actuator*

Introduction of a hydraulically operated valve actuator to cover a wide range of sizes and applications has been announced by Pacific Division, Bendix Aviation Corporation, North Hollywood, California.

The new Bendix actuator, which is being marketed under the name of the Bendix Hydrodyne Actuator, combines all the advantages of direct hydraulic power, the manufacturer asserts. The unit incorporates a simple hydraulic system that produces force in a straight line through a hydraulic cylinder to open and close the valve. As the valve seats the hydraulic pressure continues to build up, literally pressure-sealing the gate against leakage. Pressure is then hydraulically locked in the cylinder and only the reverse action will unlock it. Should pressure drop from any cause it is automatically reestablished immediately. In addition, the unit is provided with a completely independent hydraulic system, using a hand pump, for emergency.

This pressure-sealing action entirely eliminates any "bounce" or backlash in the seating operation. Further advantages of the hydraulic operation eliminates "hammer-blow" action and reduces maintenance of the entire actuator to routine inspection as the hydraulic oil serves as a lubricant for all moving parts, it is stated.

Manufacture of the Hydrodyne Actuator has been an outgrowth of the wide experience gained by the Bendix Pacific Division in the successful development of hydraulic equipment for aircraft use.



AMERICAN HEAVY DUTY ROLLER BEARINGS have built into them the vital extra capacity for continuous 24-hour-a-day performance under the most gruelling service conditions possible. Brutally strong . . . simply constructed . . . precise . . . AMERICANS operate quietly, smoothly, in the heaviest equipment under the most terrific strains and impacts. Longer, safer, lower-cost, trouble-free service is assured when AMERICAN HEAVY DUTY ROLLER BEARINGS are on the job. That's why most major manufacturers and designers of heavy industrial machinery and oil country equipment specify AMERICANS.

In your next heavy-duty installation, ride the load on AMERICANS. Our engineers will welcome your roller bearing problems. Write today.

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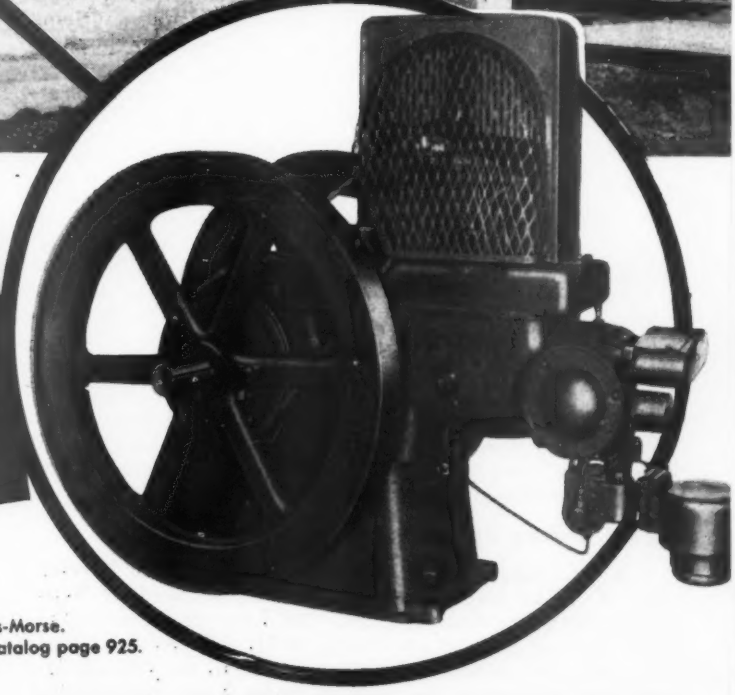
Pittsburgh **Pennsylvania**
Pacific Coast Office:
1718 S. Flower Street Los Angeles, Calif.

Cabot model CT-14L-22.5DC. See Composite Catalog pages 649-651.

WHEN POWERED WITH A
FAIRBANKS-MORSE
"ZC" ENGINE!



ZC-208 Fairbanks-Morse.
See Composite Catalog page 925.

JONES & LAUGHLIN SUPPLY COMPANY

Subsidiary of Jones & Laughlin Steel Corporation

TULSA, OKLAHOMA

J&L
STEEL

TRADE LITERATURE

Publications listed are sent free upon request.

(15) *Electronics in air filtration*

American Air Filter Company, Inc., Louisville, Kentucky, has issued a booklet titled "The Magic of Electronics in Air Filtration." Electronic air filtration is a method of removing entrained solids from air or gases by means of electric attraction. It is based on the principle that an electrically charged dust particle will be attracted to a charged electrode of opposite polarity and repelled by one of like polarity. Through electronics modern air cleaning has entered the realm of superclean air, the booklet states.

(16) *National Supply swivel*

Bulletin No. 316 of the National Supply Company illustrates and describes the company's type "V" swivel. This swivel is light in weight and of medium height, making it ideal for close-coupled derrick strings used with mast-type and other portable rigs, according to the manufacturer. It is also sufficiently sturdy and of ample capacity for any light duty service, it is stated.

(17) *"Oilwell" Wilson-Snyder slush pump*

Oil Well Supply Company, Dallas, Texas, has released bulletin Pl-645 on the "Oilwell" Wilson-Snyder No. 14-HD power slush pump (7¼ in. by 14 in.). The pump is a compact and sturdy unit with an extremely wide service range, having ample capacity to deliver a large volume of mud against pressures for heavy duty drilling, it is stated.

(18) *Dura pressure unit*

Durametallic Corporation, Kalamazoo, Michigan, has issued a new Dura pressure unit bulletin, illustrating and describing developments in a lubricating oil pressure system. This does not introduce new equipment for Dura pressure units have been manufactured for many years, however, certain improvements and developments have been incorporated in the new designs and these are described in the new bulletin.

(19) *Valves for Corrosion Service*

A new bulletin entitled "Powell Values for Corrosion Resistance" has been issued by The Wm. Powell Company, Cincinnati, Ohio. The literature describes and shows in illustration a number of the company's complete line of valves that are available in a wide selection of pure metals and special alloys for corrosion service.

(20) *Cathodic protection*

"Cathodic Protection and the Applications of Selenium Rectifiers" is the subject of a new publication in the FTR technical information series just issued by the Federal Telephone and Radio Corporation, Newark, New Jersey.

(21) *X-ray spectrometer*

A new 12-page booklet titled "Engineering-Design Development of X-Ray Spectrometer" has been announced by North American Philips Company, Inc., 100 East 42nd Street, New York. The text material was written by Mr. J. S. Buhler, technical-commercial manager, and covers in detail the basic design principles involved in the Geiger-Counter X-ray Spectrometer —recently developed industrial control tool.

(22) *Airco booklet on oxygen*

A new 24-page, two-color booklet, "Oxygen—Indispensable Servant of Industry," profusely illustrated and fully telling the interesting story about oxygen, how it is made and how it is used in industry, has been published by Air Reduction. Photographs and text tell how 99.5 per cent pure oxygen is guaranteed users and why this high oxygen purity assures economy and maximum end-use efficiency of the product.

(23) *Drilling unit*

Another bulletin in the series that Franks Manufacturing Corporation of Tulsa, Oklahoma, is preparing on its complete line of new and improved drilling and servicing equipment is now available. Franks latest bulletin features complete description, photographs, and capacities of the firm's improved Model 7000 All-Service Telescoper unit.

A heavy-duty "all-service" unit, Franks Model 7000 Telescoper is a self-propelled, power take-off, double or single drum winch unit equipped with a 90-ft., 200,000-lb. capacity, tubular telescoping derrick. This unit, composed of winch, truck, and derrick is adaptable to all servicing jobs on wells that are without derricks, it is stated. It is so designed, however, that the derrick may be disconnected and left standing on one location while the unit is moved for operation on jobs where permanent or service derrick is already a part of the well equipment.

(24) *Needle bearing handbook*

The Torrington Company, Torrington, Connecticut, and South Bend, Indiana, announces the publication of a new 153-page manual—a combined catalog and engineering and application data reference volume for designers and engineers. Entitled "Torrington Needle Bearings" and listed as Edition No. 32, it supplies all pertinent engineering information on the various needle bearings identified as types LN, DC, NCS, AT and RC.

(25) *Sterling engines*

The Sterling Engine Company, Buffalo, New York, has released a new edition of a catalog that describes and briefs the specifications of engines now in production, both marine and stationary. Included are engines with names that have long been familiar, such as the Sterling Petrel gasoline engine, the Sterling Viking gasoline and gas engine, and the famous Admiral gasoline engine in 6 and 12 cylinders.

(26) *Engine valve booklet*

A 20-page booklet covering the installation, servicing and maintenance of valves, seats and guides used in heavy-duty oil field engines has been published by Thompson Products, Inc., Bell, California. The first section of the booklet is devoted to the methods and processes used by Thompson in the manufacture of large valves, seats, and guides, and contains pictures taken at the West Coast plant illustrating the various manufacturing steps used.

In the second part, the booklet gives detailed information useful to maintenance engineers and mechanics in the installation and servicing of valves, seats, and guides.

(27) *Tool steel manual*

A 170-page, pocket-size catalog and manual, entitled "The Tool Steels of Allegheny Ludlum," has been released for distribution by the Allegheny Ludlum Steel Corporation, Brackenridge, Pennsylvania. Double the size of preceding editions, the manual provides a complete and straight-forward coverage of tool steels for all uses and users. It contains many pages of technical data and is liberally illustrated.

(28) *Acme Tool catalog*

Precision production tools are illustrated and described in a new catalog No. 45, recently published and issued by Acme Tool Company, 200 Church Street, New York 13, New York. This catalog features production tools that have contributed to increased production wherever used, according to the manufacturer.

(29) *Hortonspheroids*

The Chicago Bridge and Iron Company, Chicago, Illinois, announces the publication of a new 9-page leaflet, "The Hortonspheroid," which describes the reduction of evaporation losses from volatile liquids by storing them under pressure in Hortonspheroids. The reduction of filling, boiling, and breathing losses are discussed, together with a description of the fittings included with Hortonspheroids. Gaging methods including theoretical gage tables, tank strappings, and water calibration are described.

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 99

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue, and 95-97, inclusive, in the July, 1945, issue.

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Torrington Co., Bantam Bearings Division	(sheet 1)	258	Sept.	P 425.219.1

THE RIVETED CHAIN THAT'S EASILY ADJUSTABLE

Adjustments Easily Made on WHITNEY *Oil Field Assembly* CHAIN

NOW CONVENIENTLY PACKAGED

Offset links at regular intervals make Whitney Oil Field Assembly Chain easy to adjust for wear and elongation. Adjustments are made by *removing* one or more of these links, and since *new* link replacements are not needed, equal pitch is maintained in *all* links. *The combination of fixed shaft centers and adjustable length riveted chain assures economical operation.*

Whitney Chains are now carefully packaged to safeguard them against moisture, dirt and grit. Sealed at the factory, proper prelubrication is assured. Packages conserve storage space; facilitate handling. Write for complete specifications.

THE WHITNEY CHAIN & MANUFACTURING CO., HARTFORD 2, CONN.

It pays to specify Whitney Chains

Distributed by THE CONTINENTAL SUPPLY CO., DALLAS, TEXAS

VAPOR PRESSURE BLENDING CURVES FOR COMMERCIAL BUTANE

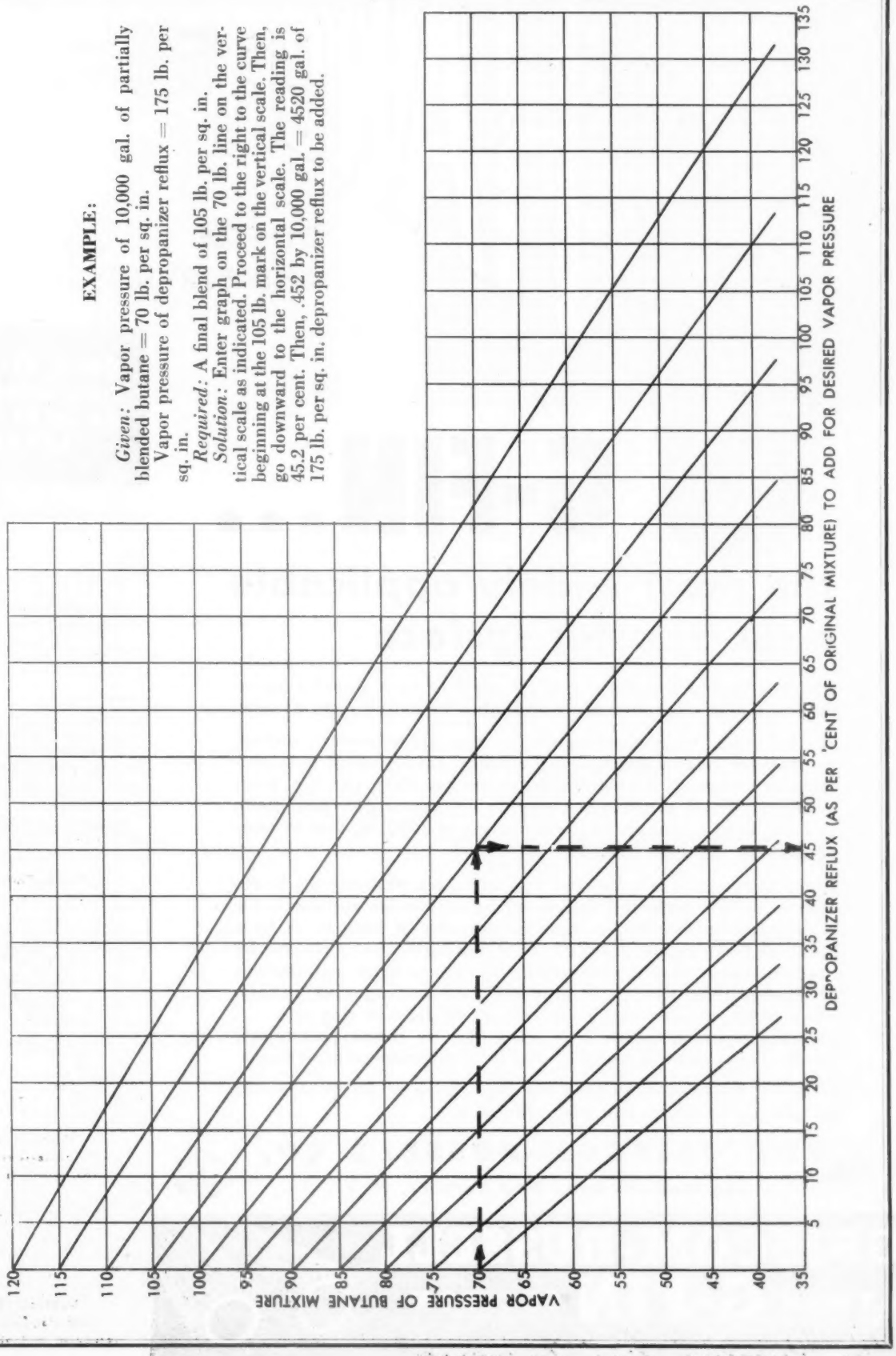
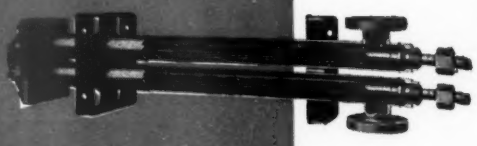

EXAMPLE:
Given: Vapor pressure of 10,000 gal. of partially blended butane = 70 lb. per sq. in.
Vapor pressure of depropanizer reflux = 175 lb. per sq. in.
Required: A final blend of 105 lb. per sq. in.
Solution: Enter graph on the 70 lb. line on the vertical scale as indicated. Proceed to the right to the curve beginning at the 105 lb. mark on the vertical scale. Then, go downward to the horizontal scale. The reading is 45.2 per cent. Then, .452 by 10,000 gal. = 4520 gal. of 175 lb. per sq. in. depropanizer reflux to be added.
VAPOR PRESSURE OF BUTANE MIXTURE
120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35
DEPROPANIZER REFLUX (AS PER CENT OF ORIGINAL MIXTURE) TO ADD FOR DESIRED VAPOR PRESSURE
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135

FIG. 2. Blending curves for butane mixture and depropanizer reflux of 175 lb. per sq. in. vapor pressure at 100°F.

RANGE

OF SIZE AND SERVICE



G-FIN...

the most widely applicable heat transfer surface

Here's a fact of significance to all users of heat transfer apparatus... G-Fin elements are applicable to every type of unit.

The list would be almost endless . . . it includes heaters, coolers, condensers, heat exchangers; the range covers small twin sections to enormous alkylation contactor bundles; and the fluids handled include practically every liquid, vapor and gas, clean or dirty, light or heavy, at pressures up to 2000 lb. and at temperatures well over 1000°F.

There are many reasons for the wide adaptability of G-Fin elements. This patented design of heat transfer surface is far more effective than bare tubes for transfer of heat to or from fluids of high viscosity or low heat conductivity . . . it can be used in standard, interchangeable units that form installations of flexible capacity . . . it provides fluid passages of uniform cross-sectional area and high velocity to prevent clogging . . . and the units in which it is used can be made particularly sturdy, convenient to handle, and with minimum maintenance.

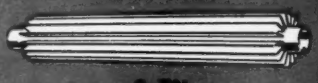
Write for bulletins describing the application of G-Fin elements to services in which you are interested.

THE GRISCOM-RUSSELL CO.

285 Madison Ave., New York 17, N. Y.

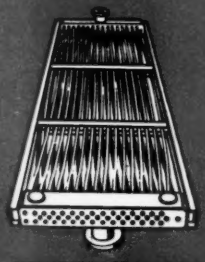
ONLY G-R BUILDS THIS WIDE VARIETY OF HEAT TRANSFER APPARATUS

SHELL and BARE TUBE
Heaters, Coolers, Condensers, Heat Exchangers

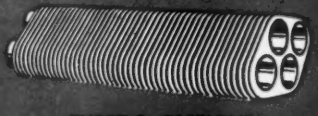


G-FIN
Longitudinal-finned elements for greater heat conductivity

K-FIN
Helical-finned elements for vapors and gases



VENTURE SECTIONS
with scale-shedding elements for hard or salt water



TUBEFLO SECTIONS
Non-clogging design for residuum and other dirty fluids

GRISCOM-RUSSELL
TWIN G-FIN SECTION
The Universal Heat Exchanger

WEIGHT INDICATOR CONVERSION TABLES

NOTE (A). A weight indicator must be properly adjusted in order to make satisfactory conversion from points to pounds. Two methods of adjusting a weight indicator are as follows:

1. When certain that the air is all out, pump up then bleed the pressure down at the diaphragm tubing connection until the distance between the shoulder of the deflection plug, which presses against the dead line and the aluminum brace plate is exactly 3/32-in. with the hook, block, and elevators hanging empty in the derrick. The gage reading will vary with the number or size of lines, the weight of blocks, hook, elevators, and height of the derrick, and it may be any figure from 3 to 10 or 12 points.

2. The following method of adjusting the weight indicator is the one used for obtaining calibration tables shown.

Occasionally check the spacing of the deflection plug. Always check it before any operation in which the total pull is important, as fishing or setting casing. This should be done with the load on the hook, or on a steel bar. Back off the clamp until the gage reads 10 points. At 10 points gage reading the deflection plug spacing should be 3/32-in. If the deflection plug spacing is not 3/32-in. at 10 points gage reading, pump up or bleed off, continually manipulating the clamp to maintain 10 points until 3/32-in. spacing has been obtained. Then clamp the line against the post again.

NOTE (B). How to interpret the weight indicator weight tables:

Example: A hypothetical rig condition may have six one inch lines strung through the traveling block, the indicating gage reads 43 points, being the total weight of the blocks, kelly, drill pipe, drill collar, bit, etc. With the empty blocks hanging in the derrick the indicating gage reads 6 points.

Correct method for finding actual load on the hook:

43 points = 95,400 lb. (Table No. 1, Six Lines Column)
6 points = 8,160 lb. (Table No. 1, Six Lines Column)

Actual Load = 87,240 lb.

Note: (Subtract loads as above. Do not subtract points.)

To obtain derrick load, the total number of drilling lines strung through the crown block should be used; e.g. in the above case at 43 points under 8 lines weight = 127,200 lb.

The weight indicator shows only the weight which is actually being carried by the lines. Because of the buoyancy effect of the mud on the drill pipe, the weight indicator reading will not check with the known weight of the pipe, blocks, hook, etc.

Example in above case, the actual load shown by the indicator is 87,240 lb. The weight of mud was found to be 10 lb. per gallon (75 lb. per cu. ft.). In the table below opposite 10 lb. per gallon, a buoyancy factor of 18.2 per cent is found. 18.2% by 87,240 lb. = 15,877 lb. 15,877 + 87,240 = 103,117 lb. actual weight of drill pipe, collars, bit, etc. in the hole.

Weight readings may be checked with actual weights by adding an amount equal to the effect of buoyancy. The necessary amounts are shown in the following table.

Lb./Gal.	*Lb./Cu. Ft.*	*Sp. Gr.*	*Per cent add to wt. ind. readings*
8	62.4	1.0	14.5
9	67.5	1.03	16.0
10	75.0	1.20	18.2
11	82.3	1.32	20.3
12	89.9	1.44	22.7
13	97.3	1.56	25.0
14	104.8	1.68	27.4
15	112.0	1.80	30.0
16	119.7	1.92	32.6
17	127.0	2.04	35.5
18	134.5	2.16	38.3
19	142.0	2.28	41.2
20	149.5	2.40	44.5

TABLE 1. Conversion table for gage readings on weight indicator with 1-in. cable. Weight indicator must be in proper adjustment to render these tables accurate.

Gage reading points	Number of lines							Gage reading points	Number of lines						
	1	2	4	6	8	10	12		1	2	4	6	8	10	12
5	1050	2100	4200	6300	8400	10500	12600	30	10055	20110	40220	60330	80440	100550	120660
6	1360	2720	5440	8160	10880	13600	16320	31	10495	20990	41980	62970	83960	104950	125940
7	1680	3360	6720	10080	13440	16800	20160	32	10935	21870	43740	65610	87480	109350	131220
8	2000	4000	8000	12000	16000	20000	24000	33	11375	22750	45500	68250	91000	113750	136500
9	2325	4650	9300	13950	18600	23250	27900	34	11820	23640	47280	70920	94560	118200	141840
10	2660	5320	10640	15960	21280	26600	31920	35	12265	24530	49060	73590	98120	122650	147180
11	2990	5980	11960	17940	23920	29900	35880	36	12710	25420	50840	76260	101680	127100	152520
12	3320	6640	13280	19920	26560	33200	39840	37	13160	26320	52640	78960	105280	131600	157920
13	3660	7320	14640	21960	29280	36600	43920	38	13610	27220	54440	81660	108880	136100	163320
14	4000	8000	16000	24000	32000	40000	48000	39	14065	28130	56260	84390	112520	140650	168780
15	4350	8700	17400	26100	34800	43500	52200	40	14520	29040	58080	87120	116160	145200	174240
16	4700	9400	18800	28200	37600	47000	56400	41	14980	29960	59920	89880	119840	149800	179760
17	5050	10100	20200	30300	40400	50500	60600	42	15440	30880	61760	92640	123520	154400	185280
18	5410	10820	21640	32460	43280	54100	64920	43	15900	31800	63600	95400	127200	159000	190800
19	5770	11540	23080	34620	46160	57700	69240	44	16365	32730	65460	98190	130920	163650	196380
20	6130	12260	24520	36780	49040	61300	73560	45	16830	33660	67320	100980	134640	168300	201960
21	6500	13000	26000	39000	52000	65000	78000	46	17300	34600	69200	103800	138400	173000	207600
22	6870	13740	27480	41220	54960	68700	82440	47	17770	35540	71080	106620	142160	177700	213240
23	7240	14480	28960	43440	57920	72400	86880	48	18245	36490	72980	109470	145960	182450	218940
24	7620	15240	30480	45720	60960	76200	91440	49	18720	37440	74880	112320	149760	187200	224640
25	8000	16000	32000	48000	64000	80000	96000	50	19200	38400	76800	115200	153600	192000	230400
26	8400	16800	33600	50400	67200	84000	100800	51	19680	39360	78720	118080	157440	196800	236160
27	8810	17620	35240	52860	70480	88100	105720	52	20160	40320	80640	120960	161280	201600	241920
28	9220	18440	36880	55320	73760	92200	110640	53	20665	41330	82660	123990	165320	206650	247980
29	9630	19260	38520	57780	77040	96300	115560	54	21150	42300	84600	126900	169200	211500	253800

—Courtesy Martin-Decker Corporation, Long Beach, California.

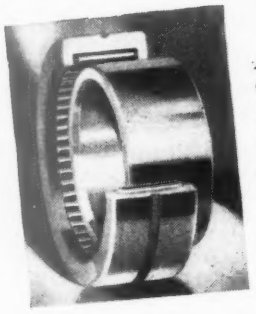
TRUCK-MOUNTED SERVICING MAST PIVOTS ON TORRINGTON BEARINGS

Designed for ease of operation and long life, the Lee C. Moore Well-Servicing Mast you see here employs Torrington NCS Needle Bearings for all seven pivot points of its mast-raising linkage. *"Torrington NCS Needle Bearings are used,"* the designers report, *"to assure long, trouble-free life in the linkage."*

Specifically designed to carry heavy loads, compact and sturdy Torrington NCS Needle Bearings are the outstanding choice, too, for pumping units, slush pumps, and many other oil-field applications.

Designing and building all types of anti-friction bearings for a wide range of oil field equipment is an important activity of Torrington's Bantam Bearings Division. Our engineers will gladly work with yours on any bearing problem, present or future.

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA



Arrows indicate application of sturdy, long-life Torrington Type NCS Needle Bearings to mast-raising linkage of Lee C. Moore Well-Servicing Mast. Torrington Bearings are used on virtually all types of modern oil field equipment.

TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

WEIGHT INDICATOR CONVERSION TABLES

TABLE 1. Conversion table for gage readings on weight indicator with 1-in. cable—*Continued.*

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
55	21635	43270	86540	129810	173080	216350	259620
56	22120	44240	88480	132720	176960	221200	265440
57	22605	45210	90420	135630	180840	226050	271260
58	23100	46200	92400	138600	184800	231000	277200
59	23600	47200	94400	141600	188800	236000	283200
60	24100	48200	96400	144600	192800	241000	289200
61	24600	49200	98400	147600	196800	246000	295200
62	25110	50220	100440	150660	200880	251100	301320
63	25630	51260	102520	153780	205940	256300	307560
64	26160	52320	104640	156960	209280	261600	313920
65	26700	53400	106800	160200	213600	267000	320400
66	27240	54480	108960	163440	217920	272400	326880
67	27780	55560	111120	166680	222240	277800	333360
68	28325	56650	113300	169950	226600	283250	339900
69	28875	57750	115500	173250	231000	288750	346500
70	29425	58850	117700	176550	235400	294250	353100
71	29985	59970	119940	179910	239880	299850	359820
72	30585	61170	122340	183510	244680	305850	367020
73	31175	62350	124700	187050	249400	311750	374100
74	31765	63530	127060	190590	254120	317650	381180
75	32355	64710	129420	194130	258840	323550	388260
76	32955	65910	131820	197730	263640	329550	395460
77	33555	67110	134220	201330	268440	335550	402660
78	34155	68310	136620	204930	273240	341550	409860
79	34755	69510	139020	208530	278040	347550	417060

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
80	35365	70730	141460	212190	282920	353650	424380
81	35975	71950	143900	215850	287800	359750	431700
82	36500	73180	146360	219540	292720	365900	439080
83	37210	74420	148840	223260	297680	372100	446520
84	37835	75670	151340	227010	302680	378350	454020
85	38465	76930	153860	230790	307720	384650	461580
86	39100	78200	156400	234600	312800	391000	469200
87	39750	79500	159000	238500	318000	397500	477000
88	40400	80800	161600	242400	323200	404000	484800
89	41050	82100	164200	246300	328400	410500	492600
90	41725	83450	166900	250350	333800	417250	500700
91	42400	84800	169600	254400	339200	424000	508800
92	43100	86200	172400	258600	344800	431000	517200
93	43800	87600	175220	262800	350400	438000	525600
94	44500	89000	178000	267000	356000	445000	534000
95	45200	90400	180800	271200	361600	452000	542400
96	45900	91800	183600	275400	367200	459000	550800
97	46600	93200	186400	279600	372800	466000	559200
98	47300	94600	189200	283800	378400	473000	567600
99	48000	96000	192000	288000	384000	480000	576000
100	48700	97400	194800	292200	389600	487000	584400

Average value of one indicator point in pounds for obtaining bit pressure in pounds—1-in. drilling line.

Between gage readings below	Number of lines						
	1	2	4	6	8	10	12
5–10	321	642	1284	1926	2568	3210	3852
10–20	344	688	1376	2064	2752	3440	4128
20–30	393	786	1572	2358	3144	3930	4716
30–40	447	894	1788	2682	3576	4470	5364
40–50	468	936	1872	2808	3744	4680	5616

Between gage readings below	Number of lines						
	1	2	4	6	8	10	12
50–60	498	996	1992	2988	3984	4980	5976
60–70	533	1066	2132	3198	4264	5330	6396
70–80	593	1186	2372	3558	4744	5930	7116
80–90	636	1272	2544	3816	5088	6360	7632
90–100	698	1396	2792	4188	5584	6980	8376

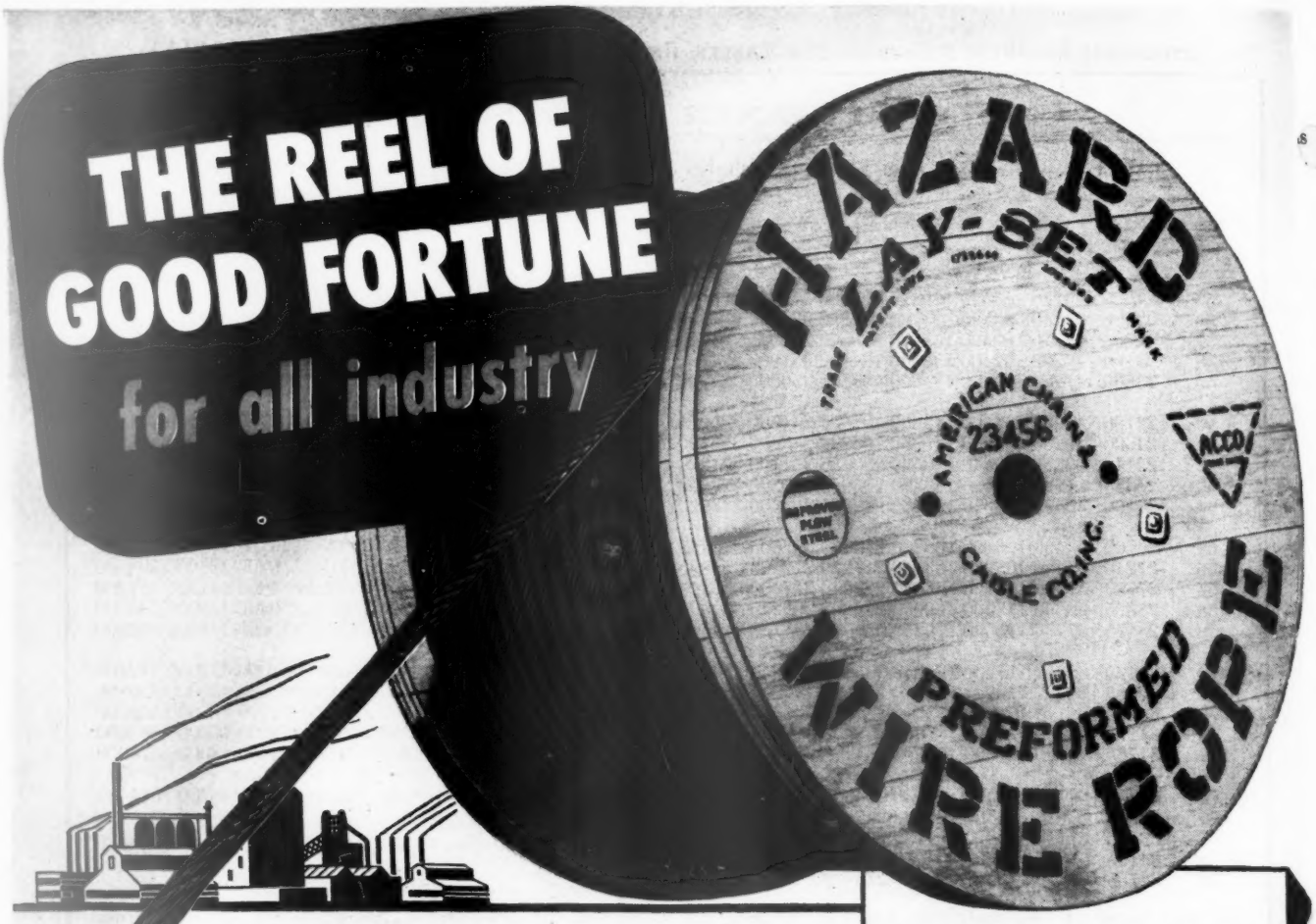
TABLE 2. Conversion table for gage readings on weight indicator with 1⅛-in. cable.
***Note:* Weight Indicator must be in proper adjustment to render these tables accurate.**

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
5	450	900	1800	2700	3600	4500	5400
6	750	1500	3000	4500	6000	7500	9000
7	1050	2100	4200	6300	8400	10500	12600
8	1360	2720	5440	8160	10880	13600	16320
9	1675	3350	6700	10050	13400	16750	20100
10	1995	3990	7980	11970	15960	19950	23940
11	2315	4630	9260	13890	18520	23150	27780
12	2635	5270	10540	15810	21080	26350	31620
13	2960	5920	11840	17760	23680	29600	35520
14	3285	6570	13140	19710	26280	32850	39420
15	3610	7220	14440	21660	28880	36100	43320
16	3940	7880	15760	23640	31520	39400	47280
17	4270	8540	17080	25620	34160	42700	51240
18	4600	9200	18400	27600	36800	46000	55200
19	4935	9870	19740	29610	39480	49350	59220
20	5270	10540	21080	31620	42160	52700	63240
21	5610	11220	22440	33660	44880	56100	67320
22	5950	11900	23800	35700	47600	59500	71400
23	6290	12580	25160	37740	50320	62900	75480
24	6630	13260	26520	39780	53040	66300	79560

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
25	6975	13950	27900	41850	55800	69750	83700
26	7320	14640	29280	43920	58560	73200	87840
27	7670	15340	30680	46020	61360	76700	92040
28	8025	16050	33100	48150	64200	80250	96300
29	8380	16760	33520	50280	67040	83800	100560
30	8740	17480	34960	52440	69920	87400	104880
31	9115	18230	36460	54690	72920	91150	109380
32	9490	18980	37960	56940	75920	94900	113880
33	9880	19760	39520	59280	79040	98800	118560
34	10270	20540	41080	61620	82160	102700	123240
35	10660	21320	42640	63960	85280	106600	127920
36	11050	22100	44200	66300	88400	110500	132600
37	11450	22900	45800	68700	91600	114500	137400
38	11850	23700	47400	71100	94800	118500	142200
39	12260	24520	49040	73560	98080	122600	147120
40	12670	25340	50680	76020	101360	126700	152040
41	13090	26180	52360	78540	104720	130900	157080
42	13510	27020	54040	81060	108080	135100	162120
43	13935	27870	55740	83610	111480	139350	167220
44	14365	28730	57460	86190	114920	143650	172380

—Courtesy Martin-Decker Corporation, Long Beach, California.

THE REEL OF GOOD FORTUNE for all industry



The new **GREEN•LUBE** made to Hazard's own specifications, clings to the wires better, thereby affording increased protection. Wires wear longer; the entire rope gives longer service. That is why *every strand* in LAY•SET Preformed I.P.S. is *packed* to the point where every void is completely filled with this superior lubricant.

LAY•SET Preformed, made of Improved Plow Steel, has long set new, high standards for wire rope service. Today it is a still better rope—thanks to **GREEN•LUBE.** This superior, more adherent lubricant makes LAY•SET I.P.S. last longer and give better, safer service because the green lubricant stays on the wires longer (more especially the inner wires) and thus not only permits of wire movement without excessive friction but better prevents corrosion. Every strand is literally packed — every void filled — every wire drenched — with this life-extending **GREEN•LUBE.** It doesn't add a dime to the price, so on your next order, be sure to specify Hazard LAY•SET Preformed All-Green Rope.

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CORRESPONDING DIFFERENTIALS—EQUAL FLOWS

FOR 3-IN. FLANGES — SIZE OF ORIFICE TO BE INSTALLED, IN.

Size of orifice plate in use, in.	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/4
1/4	1.0	.20	.06	.03	.01							
3/8	5.1	1.0	.32	.13	.06	.03						
1/2	16	3.2	1.0	.41	.20	.11	.06	.03	.01			
5/8	39	7.7	2.4	1	.48	.26	.15	.06	.03	.01		
3/4	81	16	5.1	2.0	1	.54	.32	.13	.06	.03		
7/8		30	9.4	2.9	1.8	1	.59	.24	.10	.05	.03	.02
1		50	16	4.9	3.2	1.7	1	.41	.19	.09	.05	.03
1 1/4			39	12	7.7	4.2	2.4	1	.46	.20	.08	.06
1 1/2			83	34	16	8.9	5.2	2.1	1	.34	.27	.20
1 3/4				69	33	18	9.4	4.3	2.0	1	.53	.39
2					63	34	20	12	3.6	1.8	1	.7
2 1/4						46	26	16	4.9	2.5	1.3	1

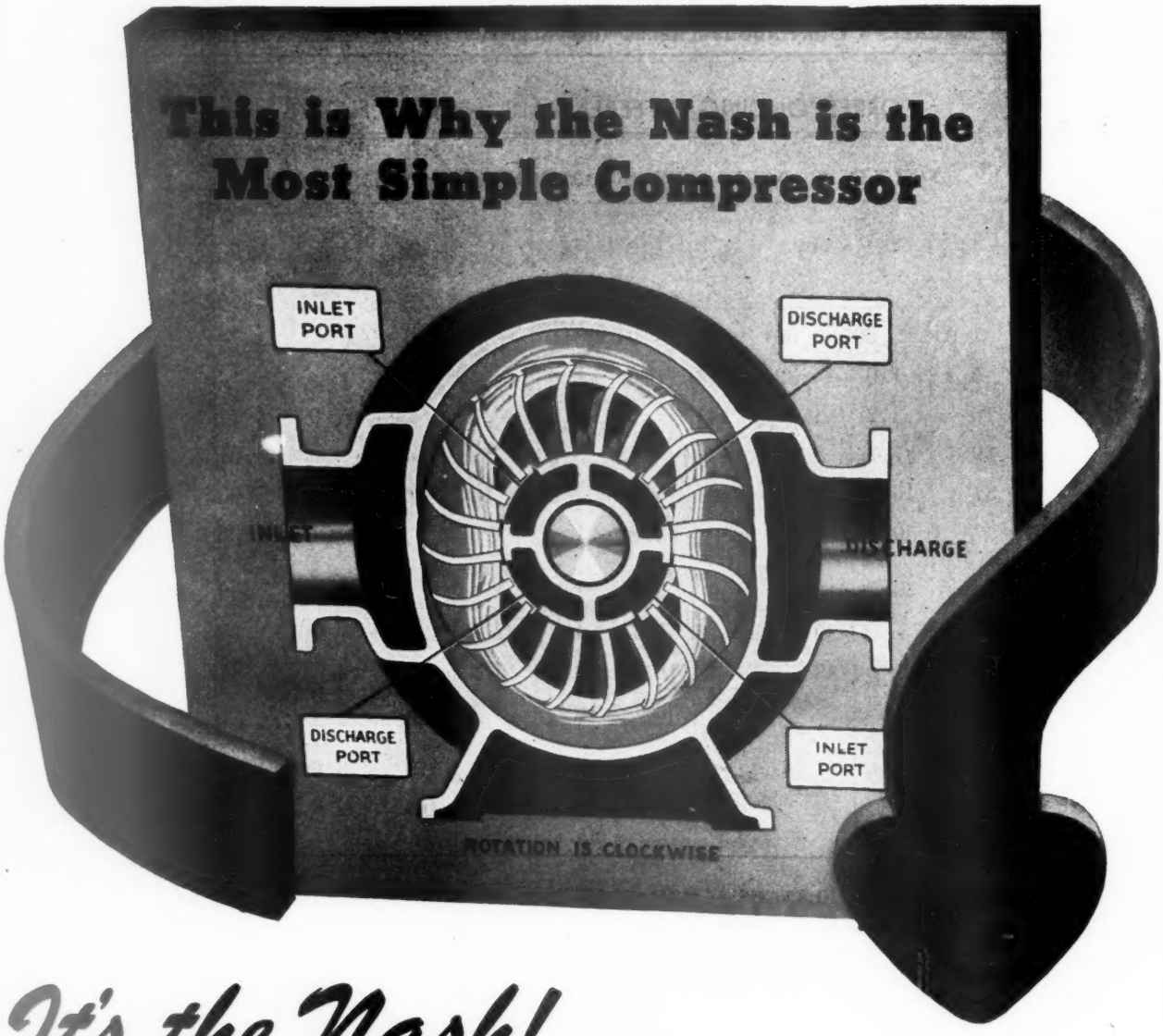
FOR 2-IN. FLANGES — SIZE OF ORIFICE TO BE INSTALLED, IN.

Size of orifice plate in use, in.	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
1/4	1	.20	.06	.03	.01						
3/8	4.9	1	.31	.12	.06	.03	.02				
1/2	16	3.1	1	.40	.19	.10	.06	.03	.02		
5/8	39	7.8	2.5	1	.47	.25	.14	.08	.05	.03	.02
3/4	82	17	5.2	2.1	1	.52	.32	.18	.11	.07	.05
7/8		31	9.9	4.0	1.9	1	.57	.34	.21	.13	.09
1		55	17	7.0	3.3	1.8	1	.60	.37	.24	.15
1 1/8		92	29	12	5.6	2.9	1.7	1	.62	.39	.25
1 1/4			47	19	9.0	4.7	2.7	1.6	1	.63	.41
1 3/8			74	30	14	7.5	4.3	2.5	1.6	1	.64
1 1/2				47	22	12	6.7	4.0	2.5	1.6	1

Formula: Multiplier = ratio of squares of orifice coefficients.

Example: If plate changed from 2-in. by .50-in. to a 2-in. by .75-in. the differential multiplier would be $\frac{(51.7)^2}{(117.8)^2} = .19$. Therefore, if the differential was reading 95-in. with the 2-in. by .50-in. plate, it would read 18-in. with the 2-in. by .75-in. plate.

This is Why the Nash is the Most Simple Compressor



It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

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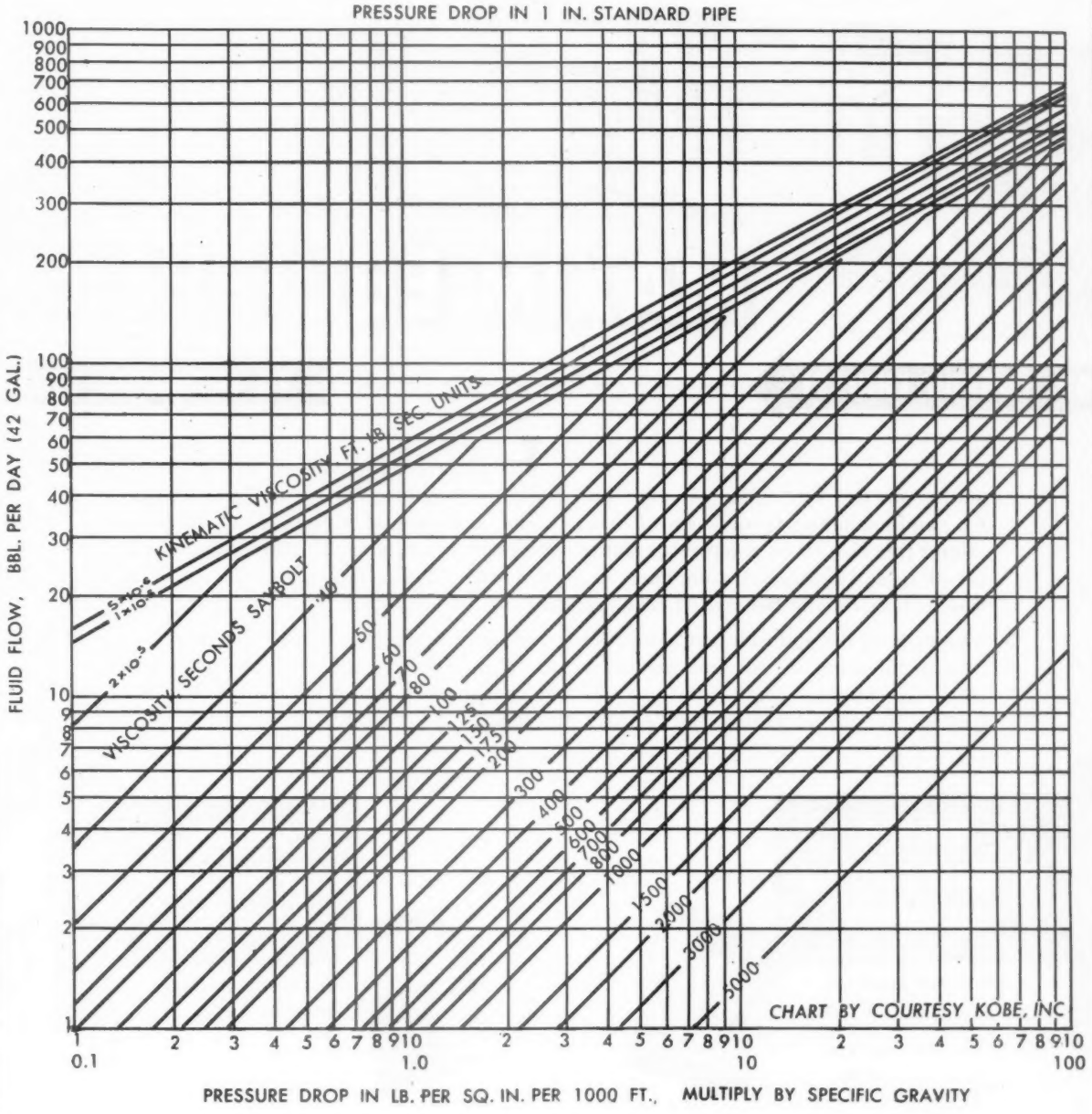
PRESSURE DROP CALCULATION CHARTS



Note: This chart is not applicable in cases where gas is present in sufficient quantity to break out of solution, or where the fluid characteristics are not uniform.

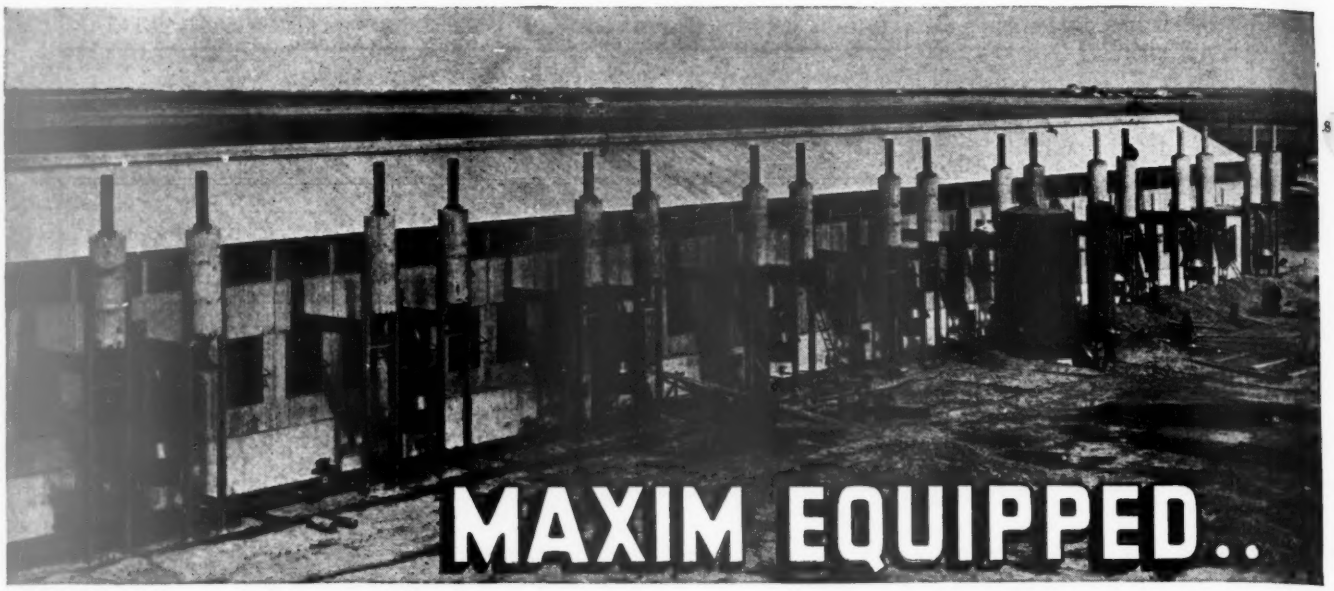
Example:

Given: Rate of flow = 100 bbl. per day.
Viscosity of fluid = 100 sec. Saybolt.
Specific gravity = 0.82.

Wanted: Pressure drop through 5000 ft. of 1 in. standard pipe.

Solution: Beginning at the 100 bbl. per day point on the fluid flow scale follow the horizontal line to the right to the point where this line crosses the 100 viscosity-sec. Saybolt line. Continue straight downward from this point and read the pressure drop = 14 lb. Multiply this figure by 0.82 gravity. This gives the pressure drop per 1000 ft. under these conditions = 11.48 lb. Multiply the result by 5 (the number of 1000's of ft.). The answer is the result of the last multiplication:

The pressure drop = 57.40 lb. through 5000 ft. of 1.05 I.D. standard pipe when the rate of flow is 100 bbl. per day, the viscosity 100 sec. Saybolt, and the specific gravity 0.82.



MAXIM EQUIPPED..

FROM CORPUS CHRISTI ---------- TO CORNWALL STATION

The picture above shows a compressor station on the 1265 mile gas pipe line, built by Tennessee Gas and Transmission Co., and extending from Corpus Christi, Texas, to Cornwall Station, West Virginia. Along this line seven compressor stations maintain pressure in the 24-inch pipe, and all of these stations are completely equipped with Maxim Silencers, such as those shown here on the Bernard, Texas, station.

Throughout the industry, on compressor stations, recycling stations, refineries, etc., Maxim Silencers are in wide use today, providing effective silencing of exhaust or intake on internal combustion engines and compressors, and where there is a fire hazard present, providing 100% spark arresting.

These Maxim Silencers (model MUC illustrated) are designed to silence the exhaust or intake of internal combustion engines, steam engine exhaust, air compressor intake, vacuum pump discharge and the intake or discharge of blowers of the positive pressure type. Wide choice of models to fit varying space and silencing requirements. Spark arresting where necessary.

Maxim Heat Recovery Silencers combine efficient silencing of engine exhaust with spark arresting (where necessary) and with the efficient recovery of waste exhaust heat to produce steam or hot water for heating or processing operations. These Heat Recovery Silencers give highly efficient heat transfer . . . are available with automatic controls, and may be run wet or dry without injury to the unit.

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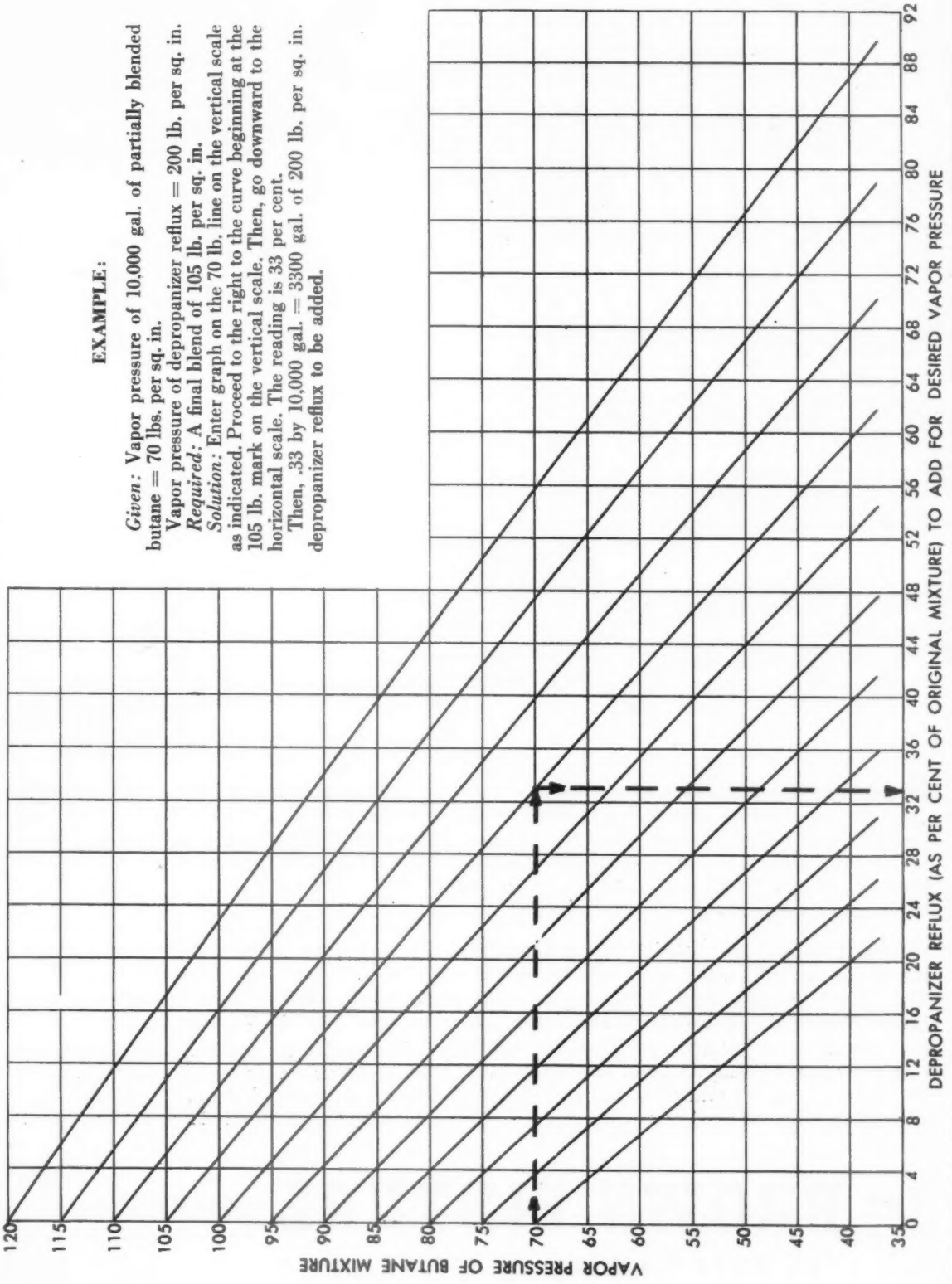
VAPOR PRESSURE BLENDING CURVES FOR COMMERCIAL BUTANE



EXAMPLE:

Given: Vapor pressure of 10,000 gal. of partially blended butane = 70 lbs. per sq. in.
Vapor pressure of depropanizer reflux = 200 lb. per sq. in.
Required: A final blend of 105 lb. per sq. in.
Solution: Enter graph on the 70 lb. line on the vertical scale as indicated. Proceed to the right to the curve beginning at the 105 lb. mark on the vertical scale. Then, go downward to the horizontal scale. The reading is 33 per cent.
Then, .33 by 10,000 gal. = 3300 gal. of 200 lb. per sq. in. depropanizer reflux to be added.

FIG. 3. Blending curves for butane mixture and depropanizer reflux of 200 lb. per sq. in. Vapor pressure at 100°F.

This Ring Joint Seal featured exclusively in BROWN FINTUBE Sectional Heat Exchangers

Recognized by engineers everywhere as the ideal closure, this ring joint seal assembly avoids packed joints, glands, ground joint seals, screw unions, and all the operating and maintenance troubles resulting from ground joint and screw union construction.

Seating surfaces of the shell flange and fintube fitting are in full view, and easily accessible. They can be wiped clean of all grit and dirt before closing the seal,—not possible with inside ground joint construction. The soft metal ring overcomes any slight unevenness of the seating surfaces, and permits tight, leak-proof closures to be made time after time.

Enthusiastically endorsed by operating and maintenance departments of oil refineries and chemical processing plants, the ring joint seal is only one of the many exclusive features Brown Fintube Sectional Heat Exchangers can give you. Brown's exclusive "one-piece" fintubes whose high heat transfer efficiency is maintained undiminished during the entire life of the tube, —our exclusive non-removable rear end construction, and replaceable stud bolting throughout, are some of the others.

Send today for the fully descriptive catalog, and let our engineers help you in adapting Brown Fintube Sectional Heat Exchangers to your exact and individual requirements.

THE **BROWN FINTUBE** COMPANY

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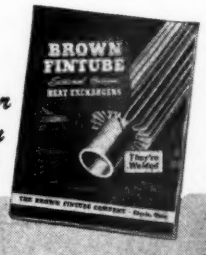
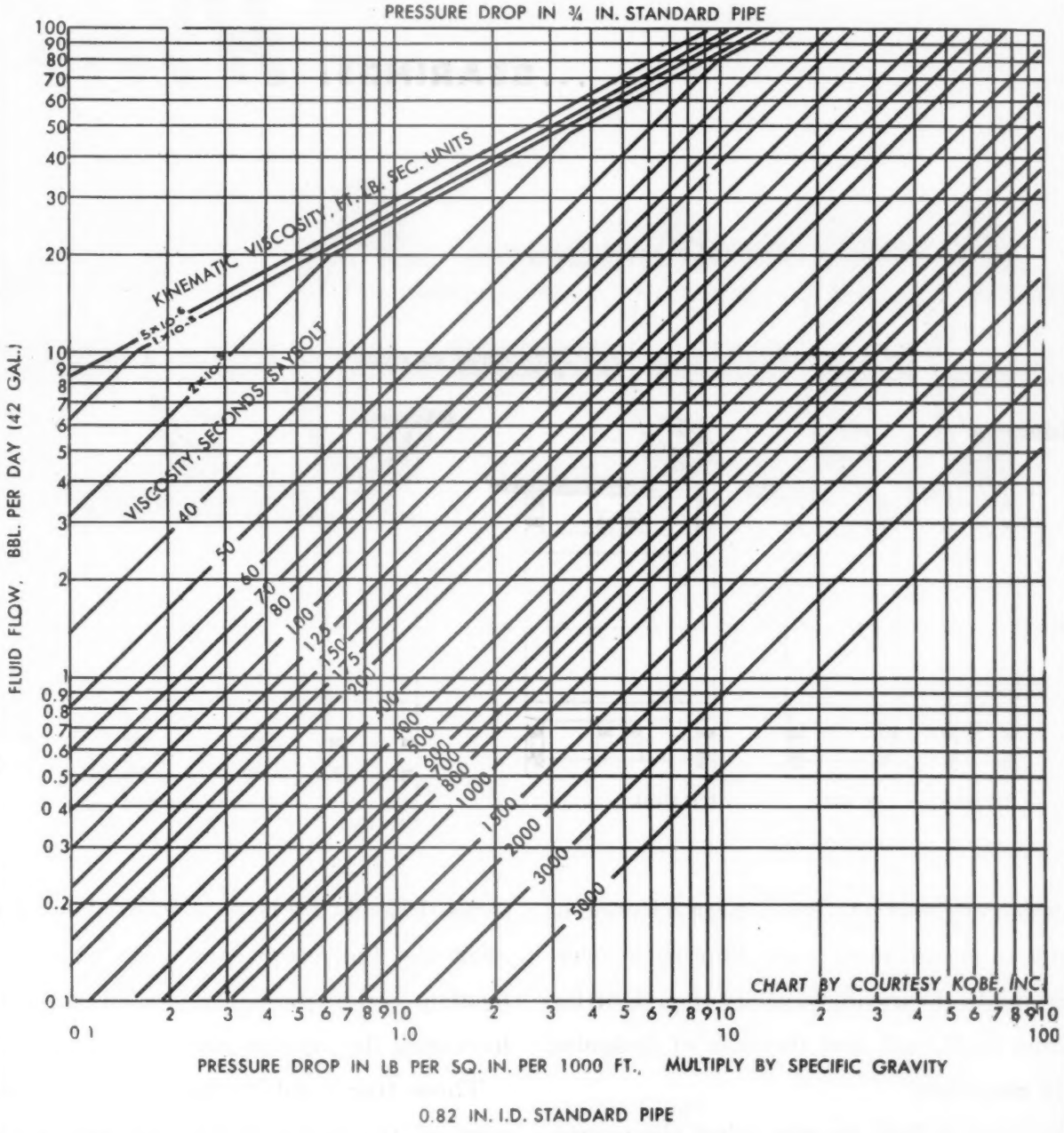
Send for Bulletin No. 452



MANUFACTURERS OF BROWN RESISTANCE WELDED INTEGRALLY BONDED ONE-PIECE FINTUBES, AND FINTUBE HEAT TRANSFER PRODUCTS

PRESSURE DROP CALCULATION CHARTS



Note: This chart is not applicable in cases where gas is present in sufficient quantity to break out of solution, or where the fluid characteristics are not uniform.

Example:

Given: Rate of flow = 100 bbl. per day
Viscosity of fluid = 100 sec. Saybolt
Specific gravity = 0.82

Wanted: Pressure drop through 5000 ft. of ¾-in. standard pipe.

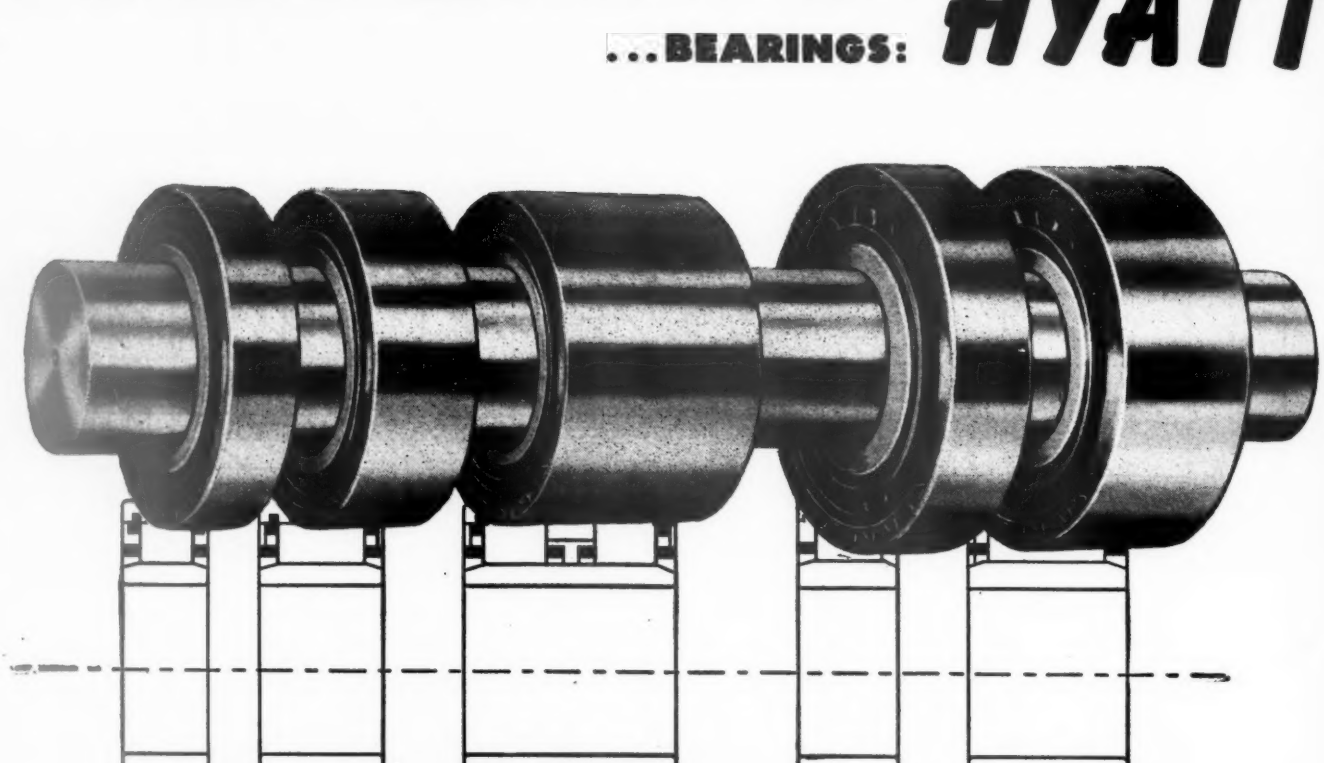
Solution: Beginning at the 100 bbl. per day point on the fluid flow scale follow the horizontal line to the right to the point where this line crosses the 100 viscosity-sec. Saybolt line. Continue straight downward from this point and read the pressure drop = 34 lb. Multiply this figure by 0.82 gravity. This gives the pressure drop per 1000 ft. under these conditions = 27.88 lb. Multiply the result by 5 (the number of 1000's of ft.). The answer is the result of the last multiplication:

The pressure drop = 139.4 lb. through 5000 ft. of 0.82 I.D. standard pipe when the rate of flow is 100 bbl. per day, the viscosity 100 sec. Saybolt, and the specific gravity 0.82.

DESIGN ADVANTAGES

in overall size and capacity...

...BEARINGS: HYATT



The design engineer who has a large selection of bearings to choose from, each differing in overall size and load-carrying capacity though fitting the same shaft, will find the task of designing greatly simplified.

If the load is light he may select the narrow width of the medium series—gaining in economy of cost, weight and space. If loads are heavy and the permissible outside diameter is limited, there are the wide and duplex widths of this same series. If loads are heavy and axial space is not available, the narrow and wide widths of the medium series provide increased capacity by increasing the annulus size.

These five combinations are available for most of the standard bearing bore sizes. All are manufactured from the same select materials and with the same precision to provide quiet, care-free operation. Ask for our Hy-Load Bearing Bulletin.

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Harrison, New Jersey · Chicago · Detroit · Pittsburgh · Oakland, California

Running Tour WITH MEN IN THE INDUSTRY

● **Lester N. Harrison** has been named southeastern district manager of the Votator Division of the Girdler Corporation, Louisville, Kentucky, with headquarters in the Johnston Building, Charlotte, North Carolina. His appointment was announced by John E. Slaughter, Jr., vice president in charge of the Votator Division. Harrison served with the Seabees as a combat driver in the Pacific Theater during the war, engaging in undersea repair and salvaging operations. He joined Votator in June, 1944, following his medical discharge.

Lester N. Harrison

● **Lee H. Hill,** vice president in charge of industrial relations at the Allis-Chalmers Manufacturing Company since 1941, has resigned his position to accept a post with the McGraw-Hill Publishing Company, New York City. He has been a member of the Allis-Chalmers organization since 1931 when the company took over the American Brown Broveri Company where Hill was manager of the transformer division. No successor for Hill has been named.

● **Paul C. Shea,** vice president of the Colonial Beacon Oil Company, has been named by The Carter Oil Company as acting manager of manufacturing for Carter's Northwest Division, according to an announcement by O. C. Schrop, president of Carter. Other appointments include that of **T. R. Corbett** as assistant manager of manufacturing and **R. D. Sloan** as division geologist. Shea, on leave-of-absence from Colonial Beacon for a minimum period of one year, replaces **T. J. Landry,** who resigned from Carter in June, 1945, to become a Carter marketing distributor at Kalispell, Montana. Corbett entered active employment of the Yale Oil Corporation as chemist. At the time of purchase of holdings of Yale by Carter, he was refining engineer. Since May, 1944, he has served as Carter's chief refining engineer, Northwest Division. He will continue to have his headquarters in Billings, Montana. Sloan, formerly head of the company's scouting and statistical division, Tulsa, Oklahoma, succeeds **D. L. Blackstone** who is leaving Carter to return to the University of Missouri as associate professor of geology. Sloan joined Carter in 1933.

● **Arnold H. Smith** has been appointed as director of the foreign department of Monsanto Chemical Company, succeeding **Herbert M. Hodges,** according to Charles Belknap, president. The promotion becomes effective October 1 when Hodges will retire. Smith will be succeeded as assistant director of the foreign department by **Marshall E. Young,** formerly general export manager. The former joined Monsanto in 1922 and has served continuously with the company in various positions since that time. Young was employed by Monsanto in 1934. He became general export manager in June, 1944. Hodges will remain with Monsanto with the title of overseas director until completion of a special mission to China, India, and South Africa. Upon completion of these duties, he will retire to England where he will make his home.

● **Sigfried A. Olson, Jr.,** has been named industrial manager at Stockholm, Sweden, for the Brown Instrument Company, Philadelphia division of Minneapolis-Honeywell Regulator Company. Olson has been New York sales representative for the Brown company for the last 9 years. He will report at Stockholm upon completion of necessary transportation clearance.

● **Robert W. Young** has resumed his position as field service representative of the Pennsylvania Grade Crude Oil Association and will have his headquarters in Cleveland, Ohio, according to W. C. Wenzel, association executive manager.

● **E. D. Wacker** has been appointed general manager of the C. J. Tagliabue Division of Portable Products Corporation, Brooklyn, New York, according to Fernal R. Marlier, president of Portable Products. Wacker has been connected with Tagliabue for 22 years and has been general sales manager for the last 8 years. The selection of Wacker's successor as general sales manager has not been made.

E. D. Wacker

● **Glen R. Davis** has joined the Turner Engineering Company of Tulsa, Oklahoma. He was formerly employed with the Shell Oil Company, Tulsa.

● **Clarence L. Williams** has joined the staff of sales engineers of The Foxboro Company, Foxboro, Massachusetts, makers of industrial instruments for measurement and control. He will maintain headquarters in the company's New York office, 520 Lexington Avenue. He has been assigned to the northern New Jersey territory and has already entered upon his new duties.

● **Major T. J. Fulson** has returned to his post as assistant division petroleum engineer of Humble Oil and Refining Company's Gulf Coast division after 3½ years in the Army. Except for a special mission to the Middle East in the summer of 1944, Major Fulson had been in the India-Burma theater since going overseas in November, 1943. He was technical operations officer assisting in the planning for and coordinating of construction and operation of approximately 3500 miles of military pipe line system from India into China. He returned to the states the last of June and was released from active duty after having been given official commendation for outstanding performance of his duties. He joined Humble in August, 1934.

● **Harold Q. Noack** has been appointed by Phelps Dodge Copper Products Corporation to serve as Pacific Coast manager, directing the sales of copper wire, tubing, cable, and other products. His territory will include Washington, Oregon, Idaho, California, Nevada, Arizona, Oklahoma, Texas, New Mexico, Utah, and the Hawaiian Islands with headquarters at the company's Los Angeles plant. For more than 20 years, Noack held the position of Pacific Coast sales manager of Hubbard and Company in charge of the western sales of electrical pole line hardware for this concern. He is past president of Emeryville Industries and is a member of The Transportation Club, Engineer's Club, and Family Club of San Francisco.

Harold Q. Noack

● **J. R. Fitz-Hugh** has been appointed head of the newly organized Carter Oil Company economics department. He has been with the company for the past year serving as coordinator of refining and manufacturing operations. Previous to that time he was with Standard of Louisiana as process engineer at the Baton Rouge Refinery.

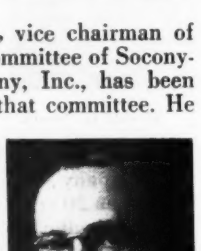
● **Orville Judd,** associate director of the fuel division of OPA, has resigned his position and will return to private industry. He has been with OPA since its beginning.

● **Walter Hochuli,** director of marketing and distribution for PAW since April 1943, has resigned his duties and has returned to The Texas Company where he was previously employed. He served on a number of committees dealing with the wartime petroleum situation and was chairman of the domestic operating committee.

● **Bushrod Brush Howard** has been elected to the board of directors of Standard Oil Company of New Jersey, according to Ralph W. Gallagher, chairman of the board. He becomes the eleventh director, following the recent retirement of Wallace E. Pratt. Howard joined the Jersey Company's marine operating division in 1920 and has served in numerous offices since that time.

He became managing operator of Societe Auxiliare de Transports in 1925 and later director of l'Economique and Bedford Petroleum Company, French affiliates with headquarters in Paris. In 1929 he went to London for the company and returned in 1934 to become assistant manager of marine operations. In 1941 he went to England at the request of the British Board of Trade, as Admiral Land's representative to expedite tanker turn-arounds in British ports and speed up deliveries of vitally needed oil from the United States. In 1942 he went to India and the Suez area as representative of the War Shipping Administration, on the British-American mission that sought to speed up cargo movements involving all types of war materials flowing to India and the Middle East. He is president of War Emergency Tankers, Inc., operator of government-owned tankers for the War Shipping Administration. He is a member of the board of managers of the American Bureau of Shipping and a director of the National Federation of American Shipping and the American Merchant Marine Institute.

● **C. S. Teitsworth,** vice chairman of the manufacturing committee of Socony-Vacuum Oil Company, Inc., has been named chairman of that committee. He has been associated with Socony-Vacuum and affiliated companies for 19 years. Since 1934 he has been in the New York office of the company where he has been intimately associated with the development and commercialization of catalytic cracking. He is also a director of the Houdry Process Corporation and in 1936 was appointed to the manufacturing committee as manager for the company's Middle West refineries. Teitsworth succeeds **W. F. Burt,** who has been named vice president and a member of the executive committee.



C. S. Teitsworth

● **L. A. (Pat) Henry,** veteran pilot with 13 years of service with Standard Oil Company of Indiana, has been appointed manager of the company's aviation department in the Chicago general sales office promotion department. Henry joined the company in 1932 as a salesman in the Quincy, Illinois, sales division and has served continuously with the company since that time. He is succeeded as sales promoter for domestic heating oils and diesel fuels by **A. J. Maltz. John P. Porter,** Standard's aviation salesman for almost 20 years, has become airlines representative in the aviation department.

● **John W. Harwood,** president of the Harwood Oil Company, Wichita, Kansas, died at his home in Wichita on August 22. He entered the oil business in 1907 and went to Wichita in 1927. He was 56 years of age.

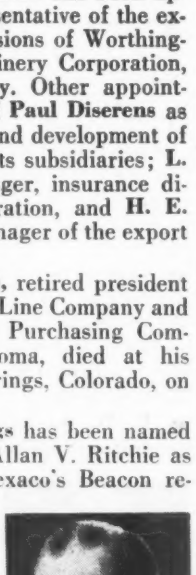
● **J. A. McCutchin,** who for the last 2 years was manager of the production division for British American Oil Company, Ltd., Calgary, Alberta, Canada, has resigned and accepted a position with the Illinois-Indiana division for Sohio Petroleum Company. He will be manager of the division with headquarters at Mt. Vernon, Illinois.

● **Clyde W. Smith,** manager of the safety department of Standard Oil Company of Indiana, who established the first safety department in the petroleum industry at the company's Whiting, Indiana, refinery, has retired because of ill health. Under Smith's direction, Standard of Indiana refineries have set several world safety records and other units of the manufacturing and sales departments have won many safety awards.

● **Dean K. Chadbourne** has been appointed special representative of the export and foreign divisions of Worthington Pump and Machinery Corporation, Harrison, New Jersey. Other appointments include that of **Paul Diserens** as director of research and development of the corporation and its subsidiaries; **L. J. Shroeder** as manager, insurance division, of the corporation, and **H. E. Wood** as assistant manager of the export division.

● **Robert E. Ellison,** retired president of the Stanolind Pipe Line Company and Stanolind Crude Oil Purchasing Company, Tulsa, Oklahoma, died at his home in Manitou Springs, Colorado, on August 16.

● **Carl E. Cummings** has been named to succeed the late Allan V. Ritchie as superintendent of Texaco's Beacon research laboratory, Beacon, New York. Col. Cummings recently was released by the United States Army, which he served as deputy chief petroleum officer in the European Theater of Operations.



C. E. Cummings

He entered the service of The Texas Company June 15, 1923, after being graduated as a mechanical engineer by Johns Hopkins University. He became chief engineer at Bayonne Laboratory in 1929, and in April, 1931, went to Beacon and did engineering work in connection with Beacon Laboratory's construction. He later became engineer in charge of the engineering research department and then supervisor in charge of that department, which position he held when granted a military leave-of-absence in 1941.

● **Paul H. Ledyard** has recently been named seismograph supervisor of Southern Geophysical Company, Sinclair Building, Fort Worth, Texas. Ledyard was associated with the seismograph department of Stanolind Oil and Gas Company for 10 years before joining Southern Geophysical. He was graduated with a master of science degree in electrical engineering from the California Institute of Technology in 1935.

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Triple seating principle—Yes, due to the advanced design and revolutionary principle of Orbit Valves, you actually get... 1—Mechanical Seal, 2—Pressure Seal, and 3—Fluid Sealed Closure, Plus—two-finger operation at all pressures due to the lack of turbulence and the equalizing action found only in Orbit's FRICTION FREE operation.

Orbit Master Valve

Available through all fabricators of Xmas trees or at your local supply stores at a price comparable to other leading valves.

See Pages 2194 to 2211 In 1944 Composite Catalog.

Orbit Valves Require No Lubrication to Effect a Seal.

ORBIT VALVE COMPANY

TULSA, OKLAHOMA

● **Lawrence E. Ferguson,** formerly with Brooks-Wilson Advertising Agency of Tulsa, Oklahoma, has joined Franks Manufacturing Corporation, Tulsa. He has a wide and varied experience in the oil industry supply and equipment field, having been associated with several major supply and equipment manufacturing firms during the last 15 years. He was with Lucey Products Corporation for 9 years. Mr. and Mrs. Ferguson reside at 2150 South Cincinnati Avenue, Tulsa. They have one son, S/Sgt. Jack J. Ferguson, stationed at Independence Air Base after 9 months overseas.

Lawrence E. Ferguson

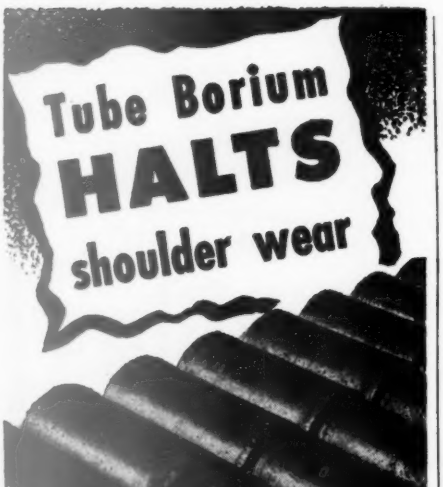
● **Maurice C. Taylor,** formerly manager of research at the Niagara Falls laboratories of The Mathieson Alkali Works, has been appointed resident director of research and development, according to an announcement by George W. Nolan, president. Other research department promotions announced are: **J. Douglas MacMahon,** assistant manager of the sales development department, to the technical director; **C. N. Richardson,** superintendent of pilot operations, to manager of research engineering; and **C. Gerald Day,** superintendent in the development department, to research and plant liaison engineer. Taylor and MacMahon will report to Dr. G. P. Vincent, recently named technical director.

● **Sidney H. Smith, Jr.,** formerly gas engineer for the Trinity Gas Corporation, Hebbronville, Texas, resigned August 1 and has accepted a position with Rogers Lacy and the Southern Gas Company at Longview, Texas, where he is gas engineer.

● **Dr. Merle R. Meacham,** manager of the Baltimore, Maryland, and Charleston, South Carolina, refineries of the Standard Oil Company of New Jersey and resident of Elizabeth, New Jersey, for many years, died Friday, August 3, in Union Memorial Hospital at Baltimore.

Born at Randolph, Ohio, December 14, 1887, Dr. Meacham attended Hiram College in Ohio for three years, transferring to Purdue University where he was graduated with the degree of bachelor of science, remaining to obtain his master's degree in chemistry. He went on to Syracuse University to receive his doctorate in chemistry. In 1918 he joined the Standard Oil Company of New Jersey as chemical engineer at the Bayway Refinery in Elizabeth. Three years later he became assistant superintendent and in 1926 was made general superintendent of the refinery. He left Bayway in 1940 to become manager of the Baltimore and Charleston refineries. He was a member of the Sigma Xi and Phi Kappa Phi fraternities and the American Chemical Society.

Interchangeable Parts
MEAN EASIER, LOWER COST VALVE MAINTENANCE
HERE'S HOW IT WORKS!
All parts of the valves shown here (except bodies and bonnet rings) fit each other perfectly. If, for example, you need a stem, disc, or seat ring for the "Renewo", you can use the corresponding part of the "Ferrenewo"—*it is exactly the same.* This means fewer parts to be carried, speedier repairs, and greater ease in making them.
Fig. 1021 150 lb. S. P. Iron Body "FERRENEWO" Regular Type
Fig. 73-P 200 lb. S. P. Bronze "RENEWO" Plug Type
● Maintenance men can give you a flock of reasons why they prefer LUNKENHEIMER quality-built Valves. Prominent among those reasons is the *wide* interchangeability of parts made possible by Lunkenheimer's highly developed simplicity of design and precision workmanship.
In the "Renewo" and "Ferrenewo" Valves, this interchangeability has long been of highest practical value to industry, in making valve maintenance easier, speeding production, lowering costs. And—vitally important today—*saving fuel* that comes from tight valves.
Lunkenheimer Distributors are located in the principal industrial centers. There is one near you. Call on him—you'll find him equipped with a COMPLETE STOCK of parts that will make Lunkenheimer "interchangeability" a time-saving, labor-saving, money-saving FACT in your plant!
The Lunkenheimer Co., Cincinnati 14, Ohio, U. S. A. Branch Offices: New York 13, Chicago 6, Boston 10, Philadelphia 7. Export Department: 318-322 Hudson St., New York 13, N. Y.
Fig. 73 200 lb. S. P. Bronze "RENEWO" Regular Type
LUNKENHEIMER VALVES
BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S. P.; BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

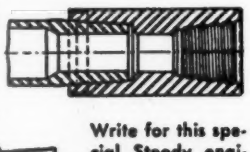


Doubles tool joint life

For fifteen years Tube Borium has been used on drilling bits to increase cutting speeds and drill more out-to-gauge hole. Now you can use this same alloy to greatly prolong the life of your tool joints!

An exceedingly small quantity of Tube Borium welded in a ring around the shoulder not only doubles tool joint life—even under the toughest operating conditions—but maintains over all joint strength and correct elevator contour. Applications are economically made on both new and resleeved joints.

APPLICATION: Accepted method of application is to under-cut new or resleeved joints at the shoulder to form a recess ⅛" deep by 1½" wide. The recess is then filled by welding in with ¾" Electric Tube Borium to form the wear resistant inlay.



Write for this special Stoody engineering bulletin describing in detail hard-facing procedures on tool joints—no obligation.

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1142 WEST SLAUSON, WHITTIER, CALIF.

STOODY HARD-FACING ALLOYS
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LAUGH WITH BARNEY

One afternoon a big wolf in a dark forest met a little girl carrying a basket of food. "Are you carrying that basket to your grandmother?" asked the wolf. The little girl said yes, she was. So the wolf asked where her grandmother lived and the little girl told him and he disappeared into the wood.

When the little girl reached her grandmother's house she saw somebody in bed with a nightcap and nightgown on. She had approached no nearer than 25 feet when she saw that it was not her grandmother but the wolf, for even in a nightcap a wolf does not look any more like your grandmother than the Metro-Goldwyn lion looks like Calvin Coolidge. So the little girl took an automatic out of her basket and shot the wolf dead.

Moral: It is not so easy to fool little girls nowadays as it used to be.

* * *

Little Johnny brought home his report card, and with it was a note from the teacher.

"Dear Mrs. Jones," said the note, "Johnny is a bright boy but he spends all his time with the girls. I'm trying to think up a way to cure him."

Mrs. Jones studied the note, then wrote the teacher as follows:

"Dear Miss Smith: If you find a way to cure him, please let me know. I'm having the same trouble with his old man."

* * *

Four young men, visiting the Orient before the war, delighted in playing all sorts of pranks on a servant. With no trace of resentment in his attitude, he brought in their coffee, day after day. Finally they decided to play no more tricks on such a good fellow, and told him so.

"No more nail shoes to floor?"

"No."

"No more put sand in bed?"

"No."

"Okay; no more put dishwater in coffee."

* * *

Housewife: And are you really content to spend your life walking about the country, begging?

Hobo: No, lady, not at all. Many's the time I wished I had a car.

* * *

The course at the aviation preflight school in Santa Ana, Calif., is said to be rather difficult. During a class, a cadet dropped a pencil that he had just removed from his pocket. After retrieving it from the floor, he turned to his classmate and asked, "What did the teacher say?"

The other cadet gaped at him and said, "What did he say? Migawd, you missed a year of college algebra!"

* * *

"Yes, offisher, I got drunk and committed bigamy."

"Ah, took one too many, eh?"

* * *

"Oh, darling," he murmured, "I love you so. Please say you'll be mine. I'm not rich like Percival Brown. I haven't a car, or a fine house or a well-stocked cellar; but darling, I love you, and I cannot live without you!"

Two soft arms stole around his neck, and two ruby lips whispered in his ear: "And I love you, too, darling, but—where is this man Brown?"

* * *

A pretty nurse, just returned from service in the South Pacific, was describing an air raid over the base where she'd been stationed. "When the Jap bombers came over," she said, "I jumped right into the nearest wolfhole."

"Don't you mean a foxhole?" interrupted a listener. "Maybe a fox dug it," replied the nurse sweetly, "but there was a wolf in it when I got there."

* * *

Hotel Guest: Hey, clerk, there are two mice fighting up here in my room.

Clerk: What do you want for $1.50—a bull fight?

* * *

Mother to Susie: Why is your right shoe muddy and not your left?

Susie: I changed my mind.

* * *

A girl doesn't mind losing her heart, she just dislikes having a man search for it.

* * *

Hotel Owner: Did you find any hotel towels in that man's suit case?

Hotel Detective: No—but I found a chambermaid in his grip.

Joe: Don't look now, but who's your closemouthed friend over there?

Moe: Oh, he ain't closemouthed. He's just waitin' fer the janitor to bring back the spittoon.

* * *

Conscience: Something that feels terrible when everything else feels swell.

* * *

Mess Sergeant: Some of the best cooks in America are in the army.

Private: What are they doing?

* * *

Little bank roll, ere we part
Let me hug you to my heart;
All the year I've clung to you—
I've been faithful, you've been true
Little bank roll, in a day
You and I will go away
To a gay and festive spot—
I'll come back, but you will not.

* * *

Private: You've never kissed me like this before, Mary. Is it because we're in a blackout?

Girl: No, it's because my name isn't Mary.

* * *

"I see by the paper that nine sergeants and one private were hurt in a wreck."

"Poor chap."

* * *

"Are you troubled with improper thoughts?"

"Naw, I enjoy them."

* * *

A fat man has one advantage over his thin brother—he knows where his cigar ashes will fall.

* * *

Mary and her boy friend had had a lot of cocktails before he took her home. He told her good night and left and Mary went to bed. After a while she looked up and saw that the ceiling was going round and round. But she just laughed, because she knew that the ceiling was plastered.

* * *

Once upon a time there was a big spinster, a middle-sized spinster and a little spinster. They came home one night and the big spinster looked in her room and said: "Somebody's been sleeping in my bed!"

The middle-sized spinster looked and said: "Somebody's been sleeping in my bed!"

The little spinster looked in her bed and yelled, "Oh, boy!"

NGAA CONDENSATE WELL CORROSION STUDIES

THE very complex problem of equipment corrosion in high pressure condensate wells is being attacked on a broadened front by a group of cooperating agencies working under the general direction of the Natural Gasoline Association of America. Entering the second year of an intensive research program, three additional studies, sponsored by the NGAA Corrosion Research Project Committee at the University of Texas, have just been announced. Each of the new projects will cover a different but related phase of the overall problem of determining the causes and possible cures for the type of corrosion found in high pressure gas wells.

One of the new projects at the university is concerned with a study of surface films on well equipment and will be under the direction of Dr. Norman Hackerman, department of chemistry. This project is to be known as the "NGAA Corrosion Fellowship." The work will involve an extensive investigation of the physical characteristics of various types of surface layers and the correlation of results with the types of corrosion attack observed in wells. This will require the setting up of sampling procedure, recording of field data from wells, the making of photomicrographs, and classification of various types of corrosion effects. The chemical nature of the films is to be determined by metallographic studies, microanalysis and electron diffraction patterns of these films. Once the character of the films actually encountered in wells is determined, attempts will be made to reproduce them in the laboratory and studies made of ways to combat the corrosive action.

A second project at the University of Texas is concerned with the varieties and concentrations of organic acids and other compounds, such as phenols, in waters taken from condensate wells, and is to be under the direction of Dr. H. L. Lochte, department of chemistry. This work involves the identification of acids through potentiometric titrations, chemical analysis, and quantitative separations made on submitted water samples. Closely allied with this work is a third study under the direction of Prof. William A. Cunningham, department of chemical engineering, which includes the routine analysis of the large number of water samples obtained from both corrosive and noncorrosive wells and from different producing horizons in dual completion wells. The committee is gathering water samples from many condensate fields in the Southwest and in California.

In discussing the new projects, T. S. Bacon, Lone Star Producing Company, Dallas, and chairman of the NGAA Corrosion Research Project Committee, stated these new studies would in no way conflict with, nor duplicate, work being done by other cooperating agencies, but would be supplementary to them.

"The necessity for finding a solution, as soon as possible, to the very destructive and expensive corrosion in wells of this type is so pressing," Bacon stated, "that every possible avenue leading to that result is to be investigated. The apparent magnitude of the problem has expanded tremendously during the past year. Serious internal corrosion has been found in many new condensate producing areas. One operator has found it necessary to replace an entire string of tubing that had been seriously weakened by internal corrosion after only seven months of service. Some instances of casing failure have been reported that might be ascribed to this type of corrosion. Field observations as reported a year ago showed corrosion of pipe and fittings to be confined largely to areas close to the wellhead, while during the past year observations clearly show this corrosion can start at the producing formation and continue on through the flow lines to the plant."

The mechanical difficulties inherent in high pressure operations have added to the complexities of the problem. "They tend to slow the work," said Bacon, "and present a real challenge to the ingenuity of research personnel in finding an economical and workable solution. This comprehensive cooperative program, although costly and necessarily slow, is fundamentally sound and the most logical way to attack the problem."

Studies of the NGAA committee in the first year of the project were largely in the laboratory but field experimentation is being expanded. Extensive laboratory studies of the corrosive action of carbon dioxide on steel in the absence of oxygen have been made and lead to the conclusion carbon dioxide may be responsible for a large part of the present corrosion. Supplemental studies were made of the effect of addition of organic acids to carbon dioxide and of the effect of various inhibitors. A satisfactory analytical procedure for quantitative determinations of the amount of organic acids present in wellhead waters has been perfected and is now being used in field surveys. Investigations have also been made of the effect of electrostatically charged particles in high pressure gas streams, using an instrument developed for the committee by Battelle Memorial Institute, and a series of field experiments is now in progress. In a study of metal alloys corroded equipment from many wells has been analyzed and the results have yielded valuable conclusions on kinds of alloys resistant to this type of corrosion. Quantitative information on rates of corrosive attack on various kinds of alloys also has been obtained in flowing wells through development of an effective technique for the exposure of metal coupons in wellhead equipment. These efforts and other lines of attack both by the committee and its individual members, have yielded highly valuable information.

Battelle Memorial Institute, Columbus, Ohio, was consulted on the problem early in 1944 and later was retained by the NGAA to conduct fundamental research and laboratory experiments as outlined by the corrosion committee. The work at the Institute is under the personal direction of Dr. H. A. Pray, who has made repeated field trips for first hand knowledge of the problems involved. Under a cooperative agreement with the NGAA, work of the U. S. Bureau of Mines is of a nature similar to that at Battelle. It is being conducted by C. Kenneth Eilerts, Bartlesville, Oklahoma, and involves laboratory and field studies of corrosive materials, resistant alloys, corrosion inhibitors, and phase distribution of water in flowing wells. The corrosion committee of the American Petroleum Institute is headed by Frank S. West, The Texas Company, Houston, who is also a member of the NGAA Corrosion Steering Committee. In addition to Bacon and West, other members of the NGAA Steering Committee are: T. W. McGuire, Cotton Valley Operators Committee, Cotton Valley, Louisiana; L. B. Wood, Phillips Petroleum Company, Bartlesville, and W. E. Winn, Sun Oil Company, Dallas. Wellhead testing of various alloys in the gas streams of corrosive wells is a project of the National Association of Corrosion Engineers under the immediate direction of Walter F. Rogers, Gulf Oil Corporation, Houston.

Serving as a clearinghouse for all the assembled information, the NGAA Corrosion Research Project Committee is the correlating agency through which duplication of effort is avoided and funds are directed into most productive channels. A total of more than $40,000 has been contributed to the committee by interested companies to further the project. Contributors to the project include the following companies: J. S. Abercrombie Company, Arkansas Fuel Oil Company, Arkansas Louisiana Gas Company, The Carter Oil Company, The Chicago Corporation, Continental Oil Company, Cotton Valley Operators Committee, Distillate Production, Gulf Plains Corporation, Humble Oil and Refining Company, La Gloria Corporation, Lone Star Producing Company, Magnolia Petroleum Company, The Ohio Oil Company, Phillips Petroleum Company, The Shamrock Oil and Gas Corporation, Shell Oil Company, Inc., Standard Oil Company of California, Stanolind Oil and Gas Company, Sun Oil Company, The Superior Oil Company, The Texas Company, Tide Water Associated Oil Company, and Union Producing Company.

★ ★ ★

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Flexitallic C-G (Compression Gauge) gaskets illustrated are available for all temperatures and pressures including the 2500 ASA flange standards.

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High or Low Temperatures
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High or Low Pressures
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Liquids, Gases, or Chemicals
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Specifically designed for actual working conditions
•
All types and shapes for all pipe flanges and pressure vessels

When Flexitallic originated resilient spiral-wound gasket construction over a third of a century ago, working pressures ranged from 150 to 300 lbs. Today, pressures of 1500 lbs. (and even 2500 lbs.) are not uncommon. Extremely high temperatures and difficult conditions involving liquids, gases, or chemicals are frequently encountered—yet, through a constant process of development, Flexitallic has solved each new problem as it arose—and has anticipated many of them. No other company has concentrated research and engineering so fully on one type of gasket construction. None other can match Flexitallic in offering a service geared to the most exacting of today's demands.

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ORIGINATORS OF THE SPIRAL-WOUND GASKET — SPECIALISTS IN SPIRAL-WOUND GASKETS EXCLUSIVELY FOR OVER A THIRD OF A CENTURY

TWO LARGE RESEARCH CENTERS TO BE BUILT

PLANS for two major petroleum research centers, construction of which will be started as quickly as steel and other materials are made available and to be completed late in 1946 or early 1947, were announced by Eugene Holman, president Standard Oil Company (N. J.)

The program will provide scientists of Standard Oil Development Company, central technical organization of the Jersey Standard group, with modern and extensive research facilities in the oil industry.

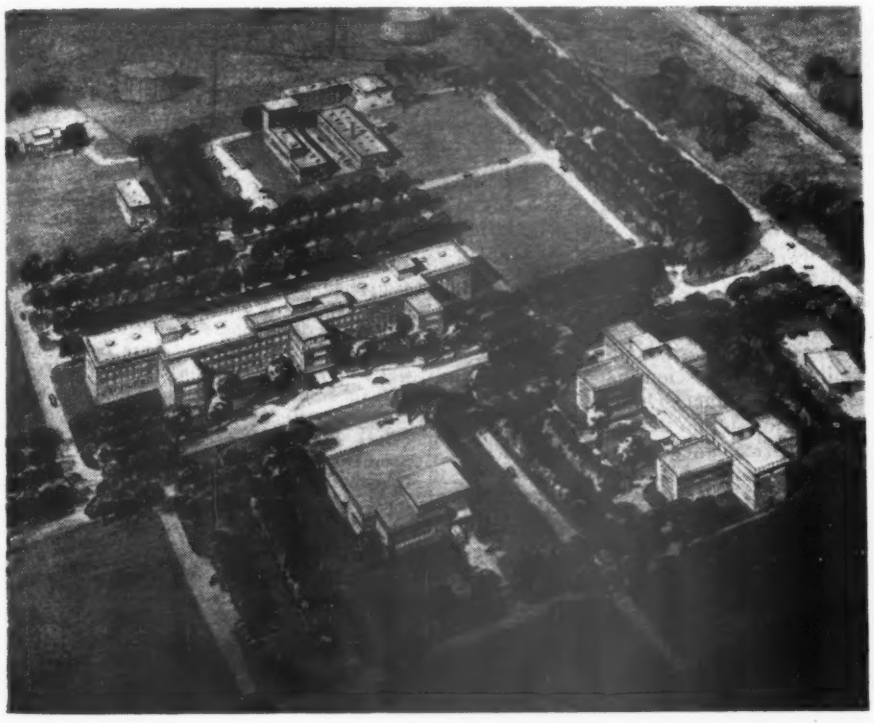
"The effectiveness of scientific research in protecting and raising the people's living standards and in opening new realms for human endeavor is one of the outstanding facts of our day," Mr. Holman said. "Free people everywhere have particular cause at this time to be grateful for the research carried out in the laboratories of our country during the past decades. From that research came the weapons that saved us from disaster and made possible the victory we are now thankfully celebrating.

"This nation, which contributed so much to the war, can contribute much to the building of the peace. To do so effectively will call for continued scientific achievement. Reconstruction, our position in the world, and the creation of conditions in which people can find security and satisfaction depend to a large degree on the energy devoted to research."

The new centers will be at Linden, N. J., and at Baton Rouge, La., at both of which places Standard Oil Development Company already has large laboratories. The expansion program ultimately may involve the expenditure of $8,000,000. At the outset eight buildings containing a total of 350,000 sq. ft. of space will be erected there in a landscaped area of 60 acres near Park and Linden Avenues, and one building containing 35,000 sq. ft. will be put up at Baton Rouge. Applications filed with the War Production Board for a major portion of the project has been approved. Construction work alone is expected to provide 1,800,000 man-hours of employment. Broken down into days, this will mean 225,000 eight-hour work days. Mr. Holman said the company had had plans and blueprints prepared and had set the start of work for the earliest possible moment in order to contribute to jobs during the reconversion period for men released from the services and from war work.

To help staff the new facilities, an increase of at least 20 per cent in the present research and technical group of 2100 will be necessary.

Adding to Mr. Holman's announcement, R. P. Russell, president of Standard Oil Development Company, said the new laboratories would be used not only for developing improved products from oil and processes for producing them but in addition extensive work on extending sources of supply of oil products would be carried out. This latter work will include production of liquid hydrocarbons from natural gas, gasification of coal, oil from coal and production of oil



This architect's drawing presents a general view of the new petroleum research center to be constructed by Standard Oil Company (N. J.) on a landscaped plot at Linden, New Jersey, as soon as materials are available and work can be got underway.

The new Esso laboratory that Standard will build on the grounds of the refinery at Baton Rouge, Louisiana. This construction is part of the expansion plan for the Standard Oil Development Company, technical division of the Standard organization.

with WEDGE Split CHILL RINGS
you can SAFELY use THIN WALL PIPE

You can now use THIN WALL pipe with safety and save money and reduce weight. WEDGE Chill Rings with the patented SPLIT Feature REINFORCE the joints which make them the strongest part of the line. Because the joints are reinforced thinner pipe can be used. You can

weld pipe and tube joints FASTER and BETTER by using WEDGE Chill Rings. You can use less skilled help and get first class work and skilled help can do much more. Use WEDGE Chill Rings for welding all refinery and line pipe joints.

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Split CHILL RINGS
SAVE MONEY

from other carbonaceous desposits such as oil shale.

Basic studies will also be conducted on the application of catalytic processes to derive chemical raw materials from petroleum. One section of the new structures will be devoted to research on extremely low-temperature polymerization, important in the field of new plastics. A process of this nature is the basis of butyl rubber, a synthetic developed by Jersey Standard and said to be superior to natural rubber for inner tubes and for certain other purposes. Discovered prior to Pearl Harbor and perfected during the war, the entire output has gone to military needs.

In addition, Mr. Russell said the company will expand its investigations in various aspects of the science of physics. Having had a part in the earlier work on the atomic bomb, it plans to keep abreast of developments involving use of atomic energy.

"We believe that these great research facilities can be an important factor in keeping the American oil industry the leader in fuels, lubricants and production of chemicals from oil and gas," Mr. Russell stated. "All practical discoveries flowing from this work will be made available to the entire industry in accord with the policy we have followed for many years.

"Everyone knows the mighty job the oil industry performed during the war in the perfection of high octane aviation gasoline, synthetic rubber, synthetic toulene for TNT and such weapons as the jellied gasoline fire bombs, flamethrowers and the smoke generator.

"Jersey Standard hopes now to do a similar job in scientific research for peacetime products. Our new laboratories are a major step in the direction of keeping America ahead in industrial research."

Keystone of the development at Linden will be a research center that will occupy 200,000 sq. ft. of a large landscaped plot on Park Avenue between the Pennsylvania railroad and U. S. Highway 1. Nearby will be constructed a separate engineering building, a motor test laboratory, a modern pilot plant structure for carrying on larger scale investigations of petroleum processes and several smaller buildings.

In addition to the most up-to-date scientific equipment, the main building will house probably the most extensive petroleum technical library in the world. Anticipating its use by educators, students and other business men, the library will contain numerous private study chambers in a large hall two stories deep.

First contracts to be awarded in the construction program have been concluded with the George A. Fuller Company of New York to cover the main research building at Linden and with John W. Harris Associates, Inc., to cover the laboratory at Baton Rouge, La. The architect for all structures is the firm of Voorhees, Walker, Foley and Smith of New York.

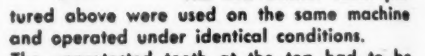
★★★

Tube Borium Keeps 'em digging

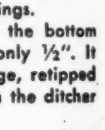
DULL IN 3 DAYS
STILL SHARP AFTER 30 DAYS
STOODY TUBE BORIUM* KEEPS DITCHER TEETH SHARP ...ELIMINATES FREQUENT SHUT-DOWNS FOR TOOTH CHANGES...CUTS REPLACEMENT COSTS UP TO 75%

The two ditcher teeth pictured above were used on the same machine and operated under identical conditions.
The unprotected tooth at the top had to be sharpened every three days and was too short for further service after six sharpenings.
But the Borium-protected tooth at the bottom operated for 40 days and wore only ½". It was simply resharpened in the forge, retipped with Tube Borium, and put back on the ditcher for another 40 days' service.
Before the tooth was finally worn out, it had operated a total of 120 days!
Tube Borium makes such savings possible because the deposits represent the ultimate in wear resistance and the ability to cut hard earth formations.

*Stoody Tube Borium is supplied in rods of ⅛", 3/16", ¼" and ⅜" diameters and is available for either oxyacetylene or D.C. electric application. Prices and specifications are yours for the asking.



These tungsten carbide particles do not melt when tube is applied but are held in suspension in a mild steel matrix forming a deposit resembling coarse sandpaper.



Send for free booklet on TUBE BORIUM, showing sizes and styles of rods and recommended methods of application.

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Small Gate Valve

Can Be Repacked Under Full Pressure

Because no pressure is transmitted to the stem, the Chapman List 960 can be repacked under full pressure. This improved small gate valve has quick-acting threads for fast opening and closing—threads that will not stick or freeze. List 960 can also be furnished with super-hardened seats and plugs for extra severe services.

Chapman List 960 is made in sizes from ¼" to 2"—carbon steel for pressures to 800 pounds; alloy steel for pressures to 1000 pounds at 750°F. For higher pressures, specify List 990.

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The CHAPMAN VALVE MFG. CO.
INDIAN ORCHARD, MASS.

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FOR EASY
MEASURING

Lufkin micrometers make quick, easy work of miking hard-to-get-at surfaces. Tapered frame slips in where clearances are small, eliminating the need for gauge blocks, parallels, and other awkward miking methods. Less chance for error in reading since each thousandth graduation on the spindle is plainly numbered. In Lufkin mikes you get easy-to-read accuracy combined with quality and superior workmanship. Order through your supply house. Write for free catalog. THE LUFKIN RULE CO., SAGINAW, MICH., New York City.

LUFKIN
FOR ACCURACY

Postwar problems discussed at conference

Standing, left to right: G. E. Gable, F. J. Kopp, R. D. Hilborn, R. C. Hunter, H. D. Stanley, H. L. Wilkins, J. K. Guinn, C. E. Robertson, A. G. Bastian, F. C. Bryan, H. U. Everett, G. B. Chapman, J. A. Evans, Jr., C. T. Owen, E. B. Thornburg, and H. H. Brown. Sitting, middle row: A. G. Chamberlain, C. E. Wilson, L. R. Roberts, M. A. Park, R. J. Woods, Jr., Rainey Elliott, Paul R. Warner, H. H. Wilson, Robert McCoy, J. L. Shakely, J. L. Goodridge, Doyne Carson, C. W. Moore, and H. E. Wagner. Bottom row: M. L. Eubank, W. L. Vinson, A. A. Hopper, J. W. Kaye, U. G. White, Jr., and J. W. Spears.

To perfect plans for meeting postwar problems in connection with supplying the material and equipment needs of the oil and gas industries, all district managers of Jones and Laughlin Supply Company were recently called to Tulsa for a three-day round-table discussion with executives and department managers. Plans were outlined for expanding and enlarging field stocks and for more efficient handling of the requirements of the oil and gas industries throughout the area served by the 76 field stores and some 15 sales offices now in operation.

This meeting is indicative of the speed and efficiency with which business is taking over postwar responsibilities. The accompanying group picture of those attending the three-day Tulsa meeting was taken at the Mayo Hotel following a dinner on the evening of August 8.

Commercial manager

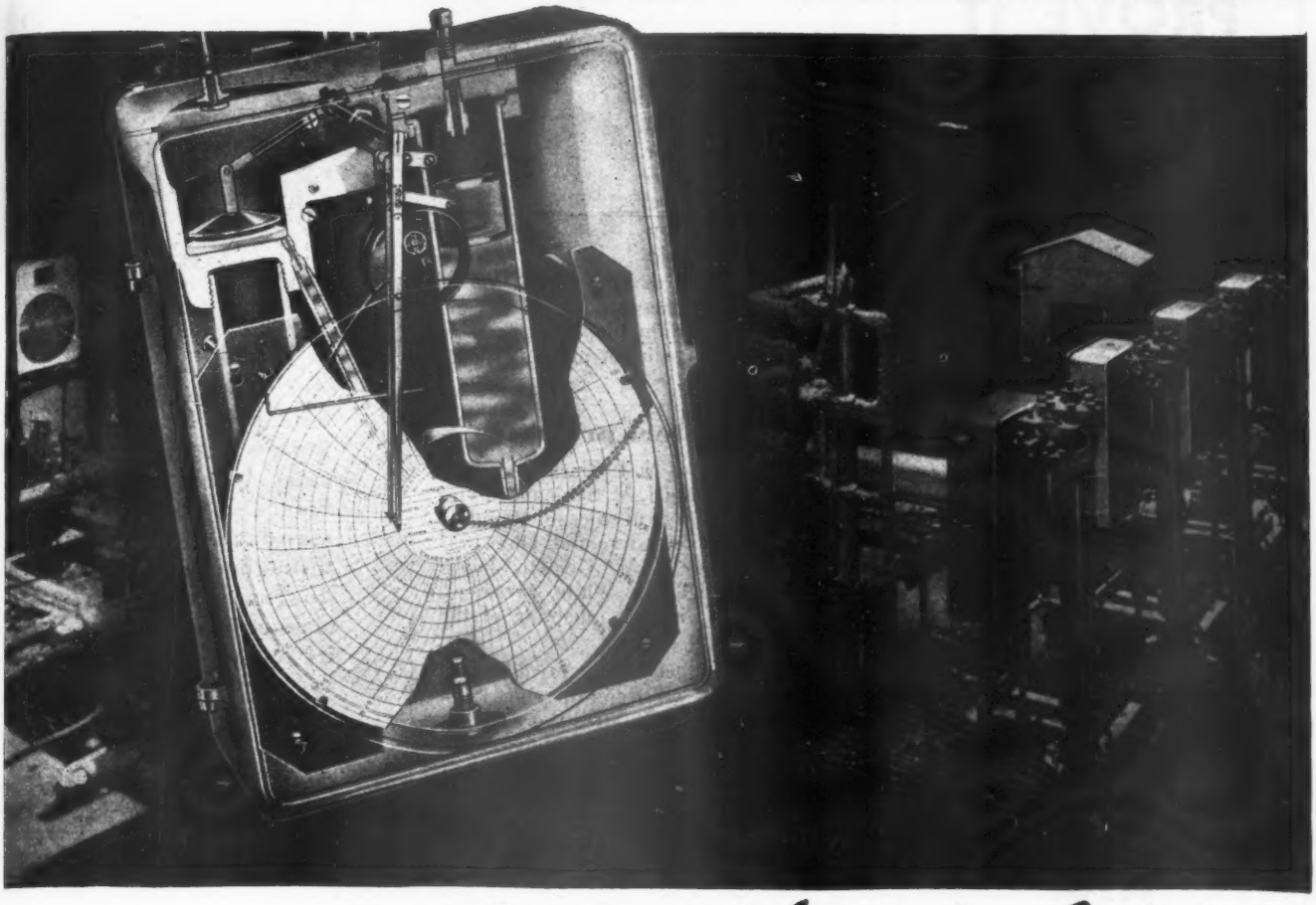
Louis J. Chatten, who resigned July 31 as director of the radio and radar division of the War Production Board in Washington, has been appointed vice president and general commercial manager of North American Philips Company, Inc., according to an announcement by O. M. E. Loupart, executive vice president. He assumed his new duties September 1.

Chatten, a member of the War Production Board since July 1943, became the director of the radio and radar division in August, 1944, in which post he had supervisory charge of the wartime output of the entire radio and electronics industry in this country.

Shaffer opens new branch

Confidence in the future of the West Texas-New Mexico area has caused Shaffer Tool Works to build a new shop on the company's own property at 1925 West 2nd Street, Odessa, Texas. This is a branch of the main plant at Brea, California, and will be operated from the Houston, Texas, branch, where Carl W. Vogt is district sales manager in charge of all Mid-Continent and Texas operations. The new Odessa branch will be in charge of James Roe. James Edgar Jackson is fishing tool operator and service man and Clarence A. Kennedy is shop mechanic. The shop is completely equipped for the service it is to perform and from this branch office will be handled all sales and service in the West Texas-New Mexico area.

Every part ACCESSIBLE FOR EASY ADJUSTMENT



. . . . out in the field!

IT TAKES a practical instrument to earn the reputation for low-cost accuracy which Westcott-AMERICAN orifice meters enjoy throughout the world.

▪ That simplicity of design and experienced engineering primarily are responsible, is obvious to any engineer familiar with flowmeter operation.

▪ But Wescott-AMERICAN orifice meters and flowmeters go still further in giving you a practical instrument: All parts are made for easy adjustment with ordinary tools. A minor feature of the Westcott-AMERICAN, to be sure . . . but an important detail in reducing the cost of accuracy out in the field.

▪ New technical literature, giving complete data, will be mailed on request. Also information on the Round Case Indicating Flowmeters, Liquid Level and Flow Controllers.

D-345

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SAND-BANUM

"The Entirely Different Boiler and Engine Treatment"

AUTOMATICALLY
Removes and Prevents Scale and Corrosion in Absolute Safety while your equipment operates.

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UNCONDITIONAL GUARANTEE

Try it entirely at our risk for 30, 60 or 90 days. It must perform to your entire satisfaction or you owe us nothing. No money in advance; not even shipping charges.

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and at other convenient points including leading supply houses
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PETROLEUM MACHINERY CORP.
30 Rockefeller Plaza New York 20, N. Y.

Reopens London office

F. Harold Gray, Reed Roller Bit Company's London representative has opened his offices in a new location at No. 59, The Wool Exchange, Coleman Street, London E. C. 2, England, and extends an invitation to all oil men passing through London to visit him.

F. Harold Gray

Gray has obtained his release from the British Army, being retired as a major. Most of his service was with the Royal Jugoslav forces operating in the Middle East, first as British liaison officer and later as commandant to a training depot for partisan forces of the Jugoslav Army of National Liberation.

Republic Steel promotes

The election of N. J. Clarke as senior vice president and J. M. Schlendorf, vice president in charge of sales, of Republic Steel Corporation, Cleveland, Ohio, was announced by T. M. Girdler, board chairman, and C. M. White, president, following the directors' meeting of the corporation.

Clarke has been vice president in charge of sales for Republic since September, 1930, shortly after the corporation was formed, and will be succeeded in that position by Schlendorf who has been assistant vice president in charge of sales.

Clarke started in 1897 with the Bourne-Fuller Company as an office boy. Successively he became salesman and manager of the company's Pittsburgh office, and returned to Cleveland in 1912 as secretary and sales manager of the Upson Nut Company which Bourne-Fuller had acquired.

His business career was interrupted by World War I when he was a major in the ordnance department. After the Armistice he returned to Bourne-Fuller as vice president and general manager and in 1919 Clarke organized and became president of the Lake Erie Bolt and Nut Company.

Schlendorf was with the American Sheet and Tin Plate Company from 1905 to 1915. During the next two years he was assistant purchasing agent of the Willys-Overland Company and in 1917 was named vice president in charge of sales of the Central Steel Company, Massillon, Ohio.

He continued in that position when Central Steel and the United Alloy Steel Corporation merged in 1926 to form the Central Alloy Steel Corporation. When that company became a part of Republic Steel Corporation in 1930 he was appointed manager of sales of the alloy steel division and in 1936 was made assistant vice president in charge of sales.

Standard Packing of the Industry

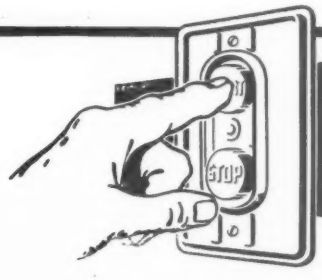
Since France Metallic Packing was patented nearly fifty years ago by Adam Warren France, it has set a high standard of excellence throughout American Industry. Users have acclaimed France Packing for its outstanding performance and durability in engines, pumps and compressors under all conditions of service. Noteworthy also is its record of decreased power and operating costs in thousands of installations.*

France Packing embodies precise metallurgical and mechanical calculations. It is pride. It is specialized effort. It is long experience and a symbol of packing satisfaction from coast to coast. Any France Packing design will reduce the maintenance bill every time.

Remember the name, FRANCE, Standard Packing of the Industry.

**Detailed information and descriptive literature mailed upon request.*

For the very best production results, tackle every job with low-cost dependable electric service . . . the power that has proved its advantages in every field. Whatever your power needs may be you'll find that electric service is not only economical but it gets the job done regardless of size.



HOUSTON LIGHTING & POWER COMPANY

Assumes new duties

The appointment of A. C. Monteith as assistant manager of headquarters engineering has been announced by M. W. Smith, vice president of the Westinghouse Electric Corporation.

Manager of the industry engineering department since 1941, Monteith will direct headquarters engineering activities in the absence of C. A. Powel, assigned to the military government of Germany with responsibility for establishing the control of electrical and radio manufacturing in that country.

At the same time, Smith announced the appointment of Monteith as director of education. In this capacity Monteith assumes overall responsibility for student recruitment and training, university relations including university visitation, scholarships, fellowships, and professorships.

These activities will be directly supervised by Charles W. MacLean, whose appointment as manager of the educational department was also announced by Smith.

Pittsburgh Piping promotes

Two executives, long with the company, have received promotions by the directors of Pittsburgh Piping and Equipment Company, Pittsburgh, Pennsylvania.

Gunnar Sinding-Larsen has been with the company for 21 years, during which time he has engineered many unusual installations in the fields of hydraulics, high pressure steam and compressed air, and in the chemical industries. He is nationally recognized as an authority in his field. Chief engineer and member of the board since 1938, Larsen now assumes the new duties and responsibilities of vice president.

Equally well known in his field is D. M. Weir, Jr., who joined the Pittsburgh Piping and Equipment Company in 1931, after an association of 14 years with the Pittsburgh Valve Foundry and Construction Company. He is a member of the Alumni Association of Carnegie Institute of Technology and Kappa Alpha Phi Fraternity, and of the ASME and the Engineers' Society of Western Pennsylvania. He belongs to the American Legion and Veterans of Foreign Wars, having served in France in World War I. Weir had served as sales engineer for the company for 14 years prior to his recent appointment as general manager of sales.

Fills new post

Paul F. Kohlhaas has been appointed to fill the newly-created position of vice president in charge of engineering of Columbia Steel Company, San Francisco, California.

P. F. Kohlhaas

Kohlhaas since 1941 has been chief engineer of Columbia Steel Company, a subsidiary of United States Steel Corporation.

For 16 years prior to his connection with Columbia he assisted in the building of iron and steel plants in England, China, Japan, Manchuria, India, and many parts of the European continent.

Two of his most interesting missions were the building of the Japanese steel mills at Yawata, Japan, and Anshan, Manchuria. For his part in these projects, Kohlhaas proved a valuable asset to the Army and Navy in the bombing of Japan's industrial areas.

In 1936 Kohlhaas became chief engineer of the Tata Iron and Steel Company, Calcutta, India. He left there in 1940 to become a technical adviser to the Brazilian Government on the construction of a steel mill at Rio de Janeiro. The following year he became associated with Columbia Steel Company.

New sales manager

Cornell and Underhill, Inc., pipe fabricators of New York and Hoboken, announces the appointment of F. Carroll Stille as sales manager. Stille for the last 20 years has been associated with the National Tube Company, both in New York and Washington, D. C., in the departments of metallurgy, research, field engineering, and sales. He will make his headquarters in the Hoboken offices of Cornell and Underhill.

For almost every *heavy duty* application where the load is radial, there is an adaptable, durable, dependable AMERICAN RADIAL ROLLER BEARING capable of withstanding the tremendous stresses and strains demanded by the ponderous equipment and stepped-up tempo of today's manufacturing. And because they are *specially* designed for "tough going," AMERICANS render smooth, continuous, trouble-free service under the most adverse operating conditions, resulting in lower maintenance costs and increased performance-life of heavy machinery and equipment.

AMERICAN RADIAL ROLLER BEARINGS are made in 5 styles, 4 S.A.E. series and 85 sizes. Special designs to order are also available. Consult our engineering department on all your roller bearing problems. Write today!

AMERICAN ROLLER BEARING CO., Pittsburgh, Pa.
Pacific Coast Office: **1718 S. Flower St., Los Angeles, Calif.**

AMERICAN ROLLER BEARINGS HEAVY DUTY

AMERICAN
Heavy-Duty ROLLER BEARINGS

Department supervisor

E. G. Cross has been recently appointed supervisor of the production planning and control department of the Crocker-Wheeler Division, Joshua Hendy Iron Works at Ampere, New Jersey. Prior to his association with Crocker-Wheeler, Cross had already gained a wide experience in the industrial management field. His background covers managerial positions in methods and procedures, contracting, accounting, material control, production control and production.

E. G. Cross

Early in his business career, Cross was associated with Merck and Company at Rahway, New Jersey, in its methods and procedures department. From there he went to the Pacific Coast where his positions included: Senior accountant at the Kaiser-owned California Ship Building Corporation; in turn, chief cost accountant, chief of material control at Pacific Aviation, Inc.; preparation and installation of production control systems in an aircraft hydraulic parts manufacturing plant and two die casting plants; production manager at the Given Machinery Company, and that of chief cost accountant and contract officer at the Western Pipe and Steel Company, San Pedro Ship Building Division.

ESSO skyscraper

One of the tallest, most modern office buildings yet announced for construction in the immediate postwar period, will be the 33-story ESSO skyscraper to be built in New York City just north of Rockefeller Center, between West 51st and West 52nd streets.

The building will cost $6,000,000. It will have 350,000 sq. ft. of rentable space. Construction will begin as soon as wartime restrictions are eased, according to the Haswin Corporation, which this week filed complete plans with zoning officials.

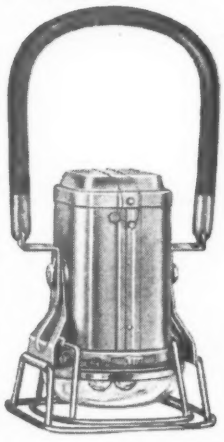
All floors with exception of the ground floor will be occupied by the Standard Oil Company (New Jersey). This space, Jersey officials said, will be used to consolidate offices at six different locations in New York City. Space in the RCA building, 30 Rockefeller Plaza, now occupied by offices of the parent organization, will be retained.

The T-shaped building, with 100-ft. frontage on one street and 274-ft. frontage on another, will have a limestone exterior and a central tower rising 424 ft. The ESSO building ground floor will house a major bank, large midtown restaurants, and other shops.

Eighteen elevators will serve the estimated 3000 persons who will work there. The building will be completely air conditioned. An immense products display center is planned for the lobby.

Rugged . . . Efficient . . . Safety Approved

JUSTRITE



Justrite Safety Lanterns and Flashlights are tops with oil men everywhere for these safety approved portable electric lights have what it takes for rugged work in the oil fields.

Take, for example, the All-Purpose Safety Lantern shown here . . . it's the finest portable light on the market and safe on many hazardous locations.

JUSTRITE ALL-PURPOSE SAFETY LANTERN

The lantern that's built of the finest materials. Twin-Bulbs for dependable light service. Has "kick-out" bulb sockets that immediately eject broken bulbs, breaking the circuit in the socket. A fixed guard protects the face of the lantern plus a movable guard-base and adjustable handle for convenience in focusing the light at any angle. Guards are sparkproofed for safety.

Listed for Safety . . . Justrite
Listed by Underwriters' Laboratories, Inc. for safety in Class I, Group D Locations, by U. S. Bureau of Mines (Approval 1017) for safe use in methane gas and air mixtures and by the Bureau of Marine Inspection for safety in pump rooms of tankers.

Ask your supplier about Justrite Safety Products

JUSTRITE MANUFACTURING COMPANY
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WISCONSIN-POWERED
Field Equipment
. . . Always "On the Beam!"

Whether operating a heavy-duty walking beam pump jack for pumping oil . . . or supplying dependable, continuous-service power for any type of power application within a 1 to 30 hp. range, Wisconsin Air-Cooled Engines are always "on the beam" . . . in terms of trouble-free service, operating economy and low upkeep cost.

Wisconsin Air-Cooled Engines are ideally adapted to field service in any locality, regardless of climatic conditions. Nothing to freeze in cold weather, no cooling problems in hot weather. High tension weather-sealed magneto with impulse coupling provides quick, easy starting at all times. Timken tapered roller bearings at both ends of the crankshaft assure smooth running and protection against bearing failure.

Specify "Wisconsin Engine" for always-on-the beam serviceability on your equipment.

ABOVE: Unit, pumping oil from Peru Sand on the Osage Indian Reservation, is powered by a Model AEH Wisconsin 4-cycle single cylinder engine (4-6 hp.)

WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
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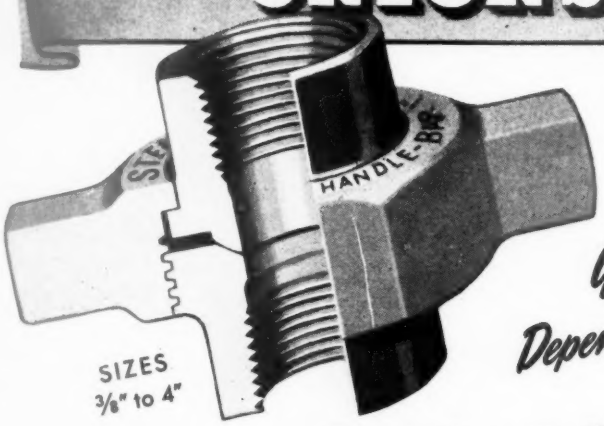
Oil field distributors for Wisconsin Engines and all types of utility units.

FORGED STEEL UNIONS



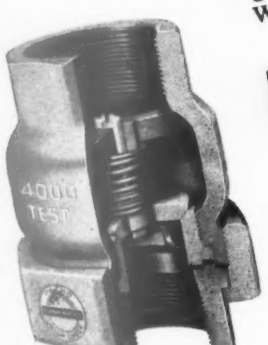
SIZES
3/8" to 4"

Your Most Dependable Servants

Handle-Bar UNION

4000 AND 6000 TEST

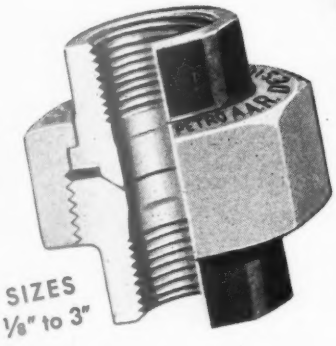
4000 Test: Sizes 3/8" to 1 1/2" V-thread in nut. 4000 and 6000 Test: Sizes 2" to 4" modified Acme Threads in nut. Steel to steel, or bronze to bronze cold rolled seats. Permanently lubricated nut threads. To tighten, or loosen the nut, USE A HAMMER INSTEAD OF A WRENCH. *Write for pamphlet 4P-HB.*



SIZES
2", 2 1/2", 3"

Petro UNION CHECK VALVE

A Check Valve that checks without shock or noise. The spring controls the opening and closing of the valve in accordance with the volume and velocity of the flow. Can be used in any position—vertical, horizontal, or upside down. Furnished as shown, or with Handle-Bar Nut. Navy bronze, or 18-8 stainless steel seats. *Write for pamphlet 4P-HB.*



SIZES
1/8" to 3"

Petro UNION

Exclusive Features that pay dividends to the User. Extra Heavy ends and Nut. Permanently lubricated nut threads. Machined and cold rolled seats. Pressures from a vacuum to 3000 lbs. Temperatures from 100° below Zero F to 1000° above Zero F. Steam, Gas, Air, Ammonia, Oil, Gasoline, Chemicals, and all services in which steel, or wrought iron pipe is used. Made to A.A.R. standards and priced in line with 300-lb. A.A.R. Malleable Iron Unions. *Write for Pamphlet AM-67.*

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FROM YOUR JOBBER

ORIGINATORS AND PIONEERS OF FORGED STEEL UNIONS

CLAYTON MARK & COMPANY

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Personnel changes

W. M. Garney, of Houston Oil Field Material Company, Houston, Texas, has been appointed business manager of the Arizona Barite Company, and will move to Phoenix, Arizona, shortly to assume his new duties. There he will work with W. F. Paine, who is production manager of this new company.

Leslie Graff

George Skipper succeeds W. M. Garney as chief clerk of the sales department. He will also work directly with the tubular goods department.

W. B. Stallings has been appointed manager of tubular goods sales and, with George Skipper, will handle all matters pertaining to sales of oil country pipe.

Otho Meadows has been transferred from field sales work at Odessa, Texas, to Harvey, Louisiana, where he has assumed his new duties as store manager.

J. B. Porterfield has been placed in charge of mud and chemical sales in the Odessa district, working in conjunction with L. L. Talley, district sales manager.

The Magnolia branch of the cutting and fishing tool department, under E. P. Sawyer, is being transferred to Shreveport, Louisiana.

The Houston Oil Field Material Company, Inc., announces the appointment of Leslie P. Graff as district engineer in South Texas. He will assist Homco's branch stores and their customers in that area with their drilling and production equipment problems. He has been engaged in this type of work since graduating from Rice Institute in 1932. Graff will reside in Alice, Texas, although his headquatrers will be in Corpus Christi, Texas.

Heads SGC

Dr. Sidon Harris has recently been named president of Southern Geophysical Company with offices in the Sinclair Building, Fort Worth, Texas. He has been associated with the geophysical industry for the last 12 years, including 10 years in the seismograph department of Stanolind Oil and Gas Company, where he was seismograph supervisor of the North Texas-New Mexico division for the last 5 years. Previously Dr. Harris was with the Humble Oil and Refining Company and has served on the faculties of Oklahoma A & M College, University of Texas, and Rice Institute. He holds a Ph.D. degree in physics from the University of Texas.

Sidon Harris

Postwar gasoline

One of the major advantages to American motorists of the extensive technical progress made in gasoline refining during the war will be in improved quality of the fuel, it is pointed out by L. H. Harvison, vice president of The M. W. Kellogg Company, petroleum engineers of Jersey City, New Jersey, and New York, New York. Analyzing the significance of the petroleum industry's vast wartime development and expansion program, Harvison emphasized that the main goal of this effort, which collectively represented one of the major feats of the war, was toward the maximum production of higher octane products to meet the urgent needs of the war program.

L. H. Harvison

The pressing demand for gasoline of 100-octane rating and higher for aviation blends, Harvison explained, necessitated extensive technical development, and plant expansion, which represented an overall industry investment totaling the huge sum of $760,000,000. The government's investment in this work aggregated about $210,000,000 or only about 28 per cent of the total. Harvison added:

"Therefore, while it is true that the improved processes now installed in many refineries may not mean an immediate reduction of gasoline prices to the consumer, it is equally true that in the postwar the consumer's gasoline dollar will buy more pulling power and general service than it did in 1941."

In this regard it is enlightening to examine the picture with respect to the consumer prices of gasoline as related to the production costs. It must be kept in mind that when the motorist pays say, 20 cents for a gallon of gasoline, he is buying only 14 cents worth of fuel as the remaining 6 cents goes for taxes; in other words he is paying a sales tax of more than 40 per cent. Of the true purchase price of 14 cents, about 8 cents represents transportation and marketing costs and slightly less than 6 cents is production and refining cost.

"Behind the matter-of-fact statement that 8 cents goes for transportation and marketing," Harvison continued, "lies one of the most impressive stories of modern sales service. It is this 8 cents, many times mutiplied, that meets the cost of bringing the gasoline to the consumer's doorstep. It pays for the whole streamlined procedure of transporting the fuel thousands of miles. Likewise it finances the maintenance of the smart efficient gas stations that ornament our major highways from coast to coast, the 24 hours servicing by these stations, map distribution, direction information, etc., which have become national by-words for courtesy and friendliness, and the countless other vital services that the American motorist has come to take for granted."

The 6-cent portion of the true purchase price represents the total that the refiner receives at the refinery for what is without doubt the top quality standard motor gasoline in the world—and that figure has not changed since prewar days.

"Termination of hostilities," he said, "leaves the petroleum industry in a notably stronger position for consumer service than ever before, even surpassing its own excellent record of technical advance and gasoline dollar value. Much of the progress made in oil refining during the war, notably in the widespread acceptance of the fluid catalytic cracking process, is equally important to peacetime operations, and will mean much to the consumer in improved quality of gasoline.

"It is still too early to forecast with any assurance the exact octane rating of gasoline that will he required for the postwar car. Obviously, this depends on the type of motor to be used. With the foresight that is part of their basic policy the technical staffs of oil and automotive industries have been working collaboratively to develop both the optimum engine and the optimum gasoline practical for consumer use in that engine. The net result of all this for the consumer will be more economical motoring."

Gas postwar outlook

Natural gas companies have been faced with a tremendous responsibility during the war emergency. During a period of increasing shortages of other fuels, this industry has supplied record quantities of natural gas for residential, industrial, and commercial uses. Natural gas industry surveys indicate that the industry is in excellent position to expand its service to the public and to other industries, and will continue to produce and deliver increasing quantities of gas in postwar years, according to R. H. Hargrove, chairman, natural gas department, American Gas Association, and vice president and general manager of United Gas Pipe Line Company.

Reserves of natural gas in the United States were recently estimated by E. DeGolyer, an outstanding geologist, at between 140,000,000,000 M. cu. ft. and 200,000,000,000 M. cu. ft. American Gas Association reported total sales of natural gas in 1944 at 2,189,392,000 M. cu. ft., approximately 1½ per cent of the nation's proved reserves of natural gas. Thus the industry has a long-term supply of natural gas on which to base its plans for expansion of its service to the public. Exploration, especially new techniques in the search for oil and gas and in drilling to deeper horizons, has in the past resulted in the discovery of increasing gas reserves and the industry is confident that it will be able to continue to find additional supplies of gas.

Total revenue from the sale of natural gas for 1944, according to the American Gas Association's report, were $677,951,900. Sales by the industry for the 12 months ended May 31, 1945, were near 8 per cent ahead of comparable period a year earlier, and it is estimated that sales in 1945 will exceed $700,000,000.

There exists a huge potential market for gas ranges, gas water heaters, gas refrigerators, and space heaters for replacement of worn equipment and installation in new homes. There is an additional postwar market for air conditioning, gas house heating equipment, and for summer and winter air conditioning units. Gas summer air conditioning, an industry that was developing about the time Germany invaded Poland, may well become a postwar giant.

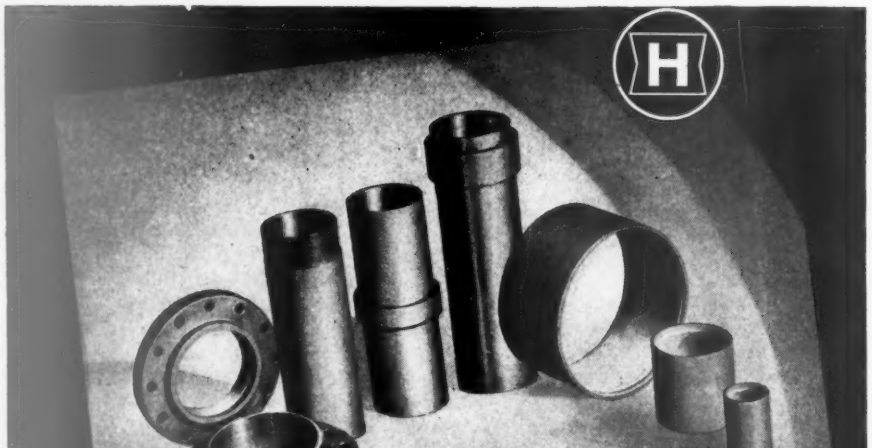
Another growing use for natural gas is being developed by the natural gas industry and by the chemical industry, using natural gas as a raw material out of which many of the substances are made that will improve living conditions in the postwar world. Natural gas companies have been experimenting and financing research projects to discover the products that can be made from natural gas. The whole industry has now combined to support a substantial research project that should open vast new markets for its product.

Looking to the possibility for extended markets, the industry has filed projects or has recently received approval of the Federal Power Commission for the construction of nearly 5000 miles of additional natural gas pipe line in this country, capable of transmitting more than 400,000,000 additional cu. ft. a day at peak movements. Hargrove called attention to the fact that a recent breakdown of postwar expenditures, made by the Federal Power Commission at the request of the American Gas Association, showed that the natural gas industry expected to spend $160,898,000 for plant expansion, maintenance and inventories and supplies in the 12 months immediately following V-E Day. Of this amount, approximately $120,000,000 would be spent on additional plants and equipment.

Industry leaders foresee an excellent opportunity to help solve the postwar employment problem. Manpower in the gas industry currently is about 10 per cent below 1939, a normal prewar year. The proposed expansion of plants and transmission facilities, development of improved products and methods of preventing waste and new processes of utilization will mean many more jobs in postwar days.

Petroleum abstracts

A new abstract service covering the latest developments in petroleum research relating to the oil industry, automotive, aeronautical, railroads and industrial fuels, lubricating oils and greases is now being issued semi-monthly by the Petroleum Research Abstracts on Fuels and Lubricants, 30 West Washington Street, Chicago 2, Illinois.



HARRISBURG

FORGED AND SEAMLESS OIL FIELD PIPING ACCESSORIES

The wide acceptance of Harrisburg Seamless Steel Couplings, Drop-Forged Pipe Flanges and Slush Pump Liners is due to their unvarying quality and extreme endurance.

Precision threading and machining operations are used to facilitate interchangeability, positive alignment and quick assembly.

Harrisburg Couplings are designed to minimize leakage, thread damage and abrasive injury from frequent use of pipe tools.

Harrisburg Drop-Forged Steel Pipe Flanges have super strength and endurance. They are made in a wide range of types and sizes.

Harrisburg Slush Pump Liners are wear resistant. Their internal surfaces are ground and polished. Diameters and threads are of a high precision standard.

Maintenance and purchasing departments should have this 102-page Harrisburg Catalog for their files. It is a source of well organized buying information and related engineering data on all Harrisburg products. Send for your copies now.

HARRISBURG STEEL CORPORATION

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Harrisburg Makes: Alloy and Carbon Steel; Seamless Steel Cylinders, Liquefiers, Pipe Couplings and Slush Pump Liners; Drop Forgings and Drop-Forged Steel Pipe Flanges; Coils and Bends.

Junior AIME meet

The August meeting of the Southern California Section of the Junior AIME, held at the Rio Hondo County Club, was devoted to a round-table discussion of drilling and production problems. Present were 31 members and 29 non-members. Serving on the panel of experts were: E. C. Babson, Ned Clark, Norris Johnston, E. K. Parks, and D. H. Sheldon. The questions and answers were as follows:

Q. What is the significance of gas saturation in ordinary core analysis?

A. With high gas saturation sand may produce gas or condensate. With high total saturation and little or no gas the sand may be a poor producer for lack of pressure.

Q. What are the methods for determining interstitial water?

A. In the field interstitial water can be determined by coring with oil base mud or by coring with water base mud, using a tracer.

In the laboratory, it is measured by determining the residual water after capillary equilibrium is reached by means of a centrifuge.

The correlation of interstitial water with permeability is as satisfactory as other core analysis relationships.

Under some conditions in the Mid-Continent it is possible to calibrate the electric log in a well where the sand contains all water and then ascertain the interstitial water in the oil pool by comparing the two curves.

Q. What is the reason for poor accuracy in the gravity determination by core analysis?

A. The distillation method probably leaves a residue in the core. If high temperatures are used, the residue may be cracked into higher gravity fractions.

Q. What is a practical present worth factor?

A. About the same as the interest rate on borrowed money.

Q. What causes drill pipe to stick where there is no salt water intrusion, no heaving shale, and when the mud water loss is low?

A. Sticking may be the result of keyseating if the hole is crooked. Use of long reamers and long drill collars will effectively eliminate the keyseat.

Mud may have a low water loss and yet a thick tough cake that will stick the drill pipe. If the mud lacks gel strength, the cuttings will fall back and may stick the pipe when circulation

FOR SALE: 4 Lufkin 3-well Hook-ups, 47.4 H.P. Gear Boxes, 74" stroke. Late Model, Complete with Jacks, Stroke Posts, Rod Lines (1"), Hold-ups and Hold-overs, Swings, V-Belts, Pulleys, Tin-Engine Houses, and each 3-well Hook-up powered by completely overhauled "E-60" Allis-Chalmers Motor.

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If you have a lease to equip within the next year, don't pass up these units. All now located on the T. O. Wright Lease, in Wright City, 5 miles East of Arp, Texas, on the Tyler-Henderson Highway.

H. W. DONNELL

Box 216 — Phone 1812 **Arp, Texas**

stops. When the rising velocity of the mud is low, the cuttings may accumulate above the drill collars and cause stuck pipe.

Q. What is the importance of gravity drainage in California oil fields?

A. Rate of recovery by gravity drainage is a function of the steepness of the sand and the mobility of the oil. In the average California reservoir, recovery of oil by gravity drainage is slow and costly. Pressure maintenance is desirable in order to keep the mobility of the oil as high as possible and to drive more oil to the producing wells.

Q. What sweep efficiency can be anticipated in pressure maintenance by gas injection?

A. Sweeping effect is an additional benefit of gas injection since the primary purpose is to recover more oil in place.

Q. How can bypassing be stopped?

A. By redrilling wells to reduce the gas-oil ratio. Pressure maintenance has been practiced in three successive steps, each of which yields diminishing returns. First, came the stopping of gas waste; second, the reduction of pool gas-oil ratios by selective withdrawal from the low-ratio wells; and third, the control of reservoirs with low gas-oil ratio. If bypassing is considerable with gas injection, more oil may be recovered by pressure depletion followed by some secondary recovery project.

Selective completions initially may be more economic than pressure maintenance. Moral: Don't take all the interval.

Q. What conditions influence the choice between water or gas for pressure maintenance?

A. The supply of gas or water is important. The size and shape of the reservoir may be a deciding factor in the choice between gas or water. If the permeability of the sand is variable, gas injection would be chosen. Where the permeability is uniform, water may be preferable.

Water may be more difficult to control and will also kill wells. Whereas, gas may bypass, but is less of a risk because wells continue to flow. As water flooding is not well known in California, the wise procedure would be to inject all gas produced by the field and, if desired, start a pilot project for water drive. It is important to remember that if pressure is maintained, the viscosity of the oil remains low, but if the pressure is depleted and then restored, the viscosity will increase and stay high after repressuring.

Q. How can saturations be determined in the pool.

A. Saturations can be determined by P.V.T. tests on subsurface samples or recombined surface samples.

Q. What is a good drilling fluid for well completions?

A. Drilling out with crude oil has given good results, especially if interval has little or no shale. Crude oil may form a plaster when mixed with shale.

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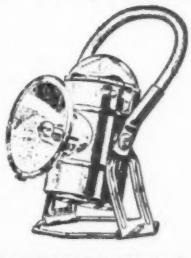
or Bright
FLOODLIGHT
WHEN YOU CARRY

ECOLITE 72

This is a safe, efficient economical lantern that gives you a strong 1500 ft. beam or a bright floodlight. It is easy to carry, tilts and pivots, gives you lots of light where needed. Carries Underwriters' Laboratories recommendation for use in Class 1 Group D Hazards. Low price. See it at once. At Oil Well Supply Stores.



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DOUBLE COATS and DOUBLE WRAPS
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This machine was especially developed for J-M by Crutcher-Rolfs-Cummings of Houston.

Here's the way to get "plus" protection for your pipelines in double-quick time!

THIS ingenious J-M machine alternately applies *two* layers of Johns-Manville Asbestos Felts and *two* coats of enamel to give protection against severe corrosive conditions.

Pioneers in the manufacture and application of asbestos wrappings . . . Johns-Manville has gone a step further with this new machine.

The J-M Coating and Wrapping Machine can save time and money for you, just as J-M Asbestos Pipeline Felts safeguard the enamel on your lines against soil stress and distortion. For further information, write Johns-Manville, 22 East 40th Street, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville *Asbestos* Pipeline Felts

Peerless sales districts

In preparation for postwar distribution of water pumps, Peerless Pump Division of Food Machinery Corporation has rearranged territorial distribution by the establishment of five sales districts.

Warner G. Vaughan has been appointed Atlantic district sales manager, with offices established in Suburban Square, Ardmore, Pennsylvania. Vaughan was for several years the company's representative in Washington, D. C., negotiating a vast quantity of government contracts for Peerless Pumps and "Water Buffalos."

The Southeastern territory has been placed under the management of Charles E. Tierney with offices in the Blair Building, 215 Church Street, Decatur, Georgia. He is well known in hydraulic circles, having devoted many years to pump engineering.

Edward W. Pierce will continue in charge of the Central territory and as district sales manager is making his headquarters at the Peerless Canton, Ohio, works.

The Southwestern territory has for its district sales manager William E. Griffin and headquarters are at 122 E. 5th Street, Plainview, Texas.

B. A. Tucker is Pacific district sales manager, with headquarters at 301 West Avenue 26, Los Angeles, California. Tucker has spent a lifetime in the pump business and for several years past was manager of the Fresno, California, division.

Bendix sales executives

Appointment of F. E. Williams as general sales manager and C. E. Sexauer as service manager of the Zenith Carburetor division of Bendix Aviation Corporation has been announced by Guy C. Fricke, general manager.

A veteran of 28 years association with the Zenith organization, pioneers in special and heavy-duty carburetion for vehicular, marine and industrial engines, Williams joined the company in 1917 in the drafting department. He later became assistant service sales manager and advertising manager and has been service manager since 1933, it was stated.

Sexauer, as a field engineer in the division's service department since 1928, has taken part in the growth and expansion of the firm's distribution and service organization.

Wartime applications of the division's commercial carburetors range from gasoline-operated Army and Navy power generating equipment to heavy-duty trucks, earth-moving equipment, landing barges, P. T. boats, and Coast Guard patrol vessels, it was stated. More than three-and-one-half million units of 375 different carburetor assemblies have been produced since Pearl Harbor to meet requirements of the armed forces, it was stated.

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The Mayo, Tulsa's finest hotel, is ideally suited for oil industry conferences. Located in the Oil Capital of the World, it's in the center of the oil country and affords convenience to the home offices of the industry's major companies. Excellent facilities for business meetings, large or small auditoriums, or private conference rooms, spacious comfortable accommodations, excellent food and courteous service.

THE MAYO

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Look for the Arm-and-Hammer

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ARMSTRONG BROS. Pipe Cutters are made in all standard types. Each is a quality tool with hardened steel pins and rollers. "Saunders Type"—hardened end of thrust rod bears on inserted hard steel block (double life). In "Drop Forged" and "Combination" types, which take either 1 or 3 wheels, a replaceable hardened steel nut takes up thrust. In the "Barnes" type thrust rod threads through drop forged steel section.
ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machined from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters. . . . *Write for Catalog.*

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. • CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York, N.Y.

Organization change

All Mid-Continent sales and service of engines, control equipment, separators and tanks will henceforth be handled by Climax Industries, Inc., factory owned distributor of the Climax Engineering Company of Clinton, Iowa, and the McAlear Manufacturing of Tulsa and Chicago (formerly Hanlon-Waters and McAlear).

Allen George will, as previously announced, have charge of all drilling and oil well pumping engine sales. He will make his headquarters at Fort Worth, Texas.

Jimmy Dvoracek has been appointed sales manager of the control division and will supervise and direct all sales of control equipment, separators, and tanks. He will retain his headquarters at Houston, Texas, and branch offices will be maintained at Corpus Christi, Wichita Falls, Odessa, Fort Worth, Texas, Houma, Louisiana, and Tulsa, Oklahoma.

New laboratory

Construction of a new test laboratory costing $750,000 and greatly extending the facilities of the research engineering division of the Elliott Company, Jeannette, Pennsylvania, is announced by Grant B. Shipley, president.

Plans for extensive research and development on gas turbine power plants have called for the construction of a new main building, 60 ft. by 140 ft., and several small buildings separate and adjacent to it. Construction has already begun and is expected to be completed within six months.

Situated adjacent to the main Elliott factory at Jeannette, Pennsylvania, the new laboratory will be of windowless construction with uniform fluorescent lighting in addition to localized floodlights.

Year around forced-draft circulation, using filtered outside air, will make possible seven complete changes of air each hour.

In view of the size of the equipment to be tested, there will be a 35-ft. clearance under a 10-ton crane, operating on a 60-ft. span, running the entire length of the building. Concrete roadways will connect the building to the main shop for convenience of transportation of equipment, and a railway siding will run into the building, making possible direct shipment of full-size gas turbine plants.

Among the permanent installations will be test stands for gas turbines, compressors and blowers, heat transfer equipment, a combustion laboratory, a metallurgical laboratory, and an experimental machine shop.

LINE SCALES

10 of the 20 Models we manufacture. 40,000 pounds to 500,000 pounds. A special scale for any job.

With a Line Scale you know the pull on the line, and the weight on the bit in pounds. Accurate, sensitive, rugged, durable and economical.

Although we are working at top capacity to supply ship yards and the U. S. Navy—we are still able to furnish Line Scales to the oil industry. Write for folder and prices. Your supply man will be glad to get you a Scale.

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EXPANSION?...YES!...60,000 SQUARE FEET OF IT ADDED TO OUR TOTAL PLANT CAPACITY

Demands for HILL-HUBBELL Steel Pipe Protection made this additional plant necessary

Location:
Girard, Ohio
(Youngstown switching area)

Your Pipe Protection requirements can be applied at our conveniently located factories.

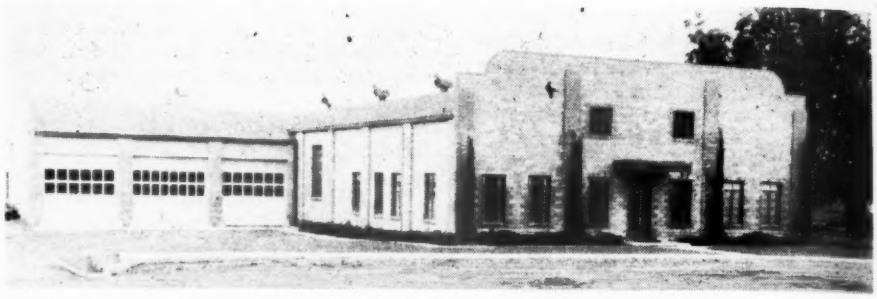
Accepted convictions are, that mechanical Cleaning—Priming—Coating—and—Wrapping of steel pipe, can best be done in or near the steel mills; indoors and unimpaired by unpredictable weather conditions. Our late designed, rugged, permanently installed type of machinery, with thermostatic controls, assure the highest quality of precision applied pipe protection.

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. •

Sales manager Olsco Gas Lift Equipment

C. D. Fletcher is the new sales manager of Olsco Gas Lift Equipment, Longview, Texas, according to announcement of Tom Cook, president. Fletcher is well known in the petroleum industry, having been in the Snowden and McSweeney organization for 23 years. Just prior to leaving he was assistant production superintendent and petroleum engineer.

C. D. Fletcher



Olsco Gas Lift Equipment plant at Longview, Texas.

In 1943 Fletcher joined the American Manufacturing Company, Fort Worth, Texas, as manager of the commercial division. He remained with that company until June, 1945, when he accepted the position of sales manager for Olsco Gas Lift Equipment.

Dow appointments

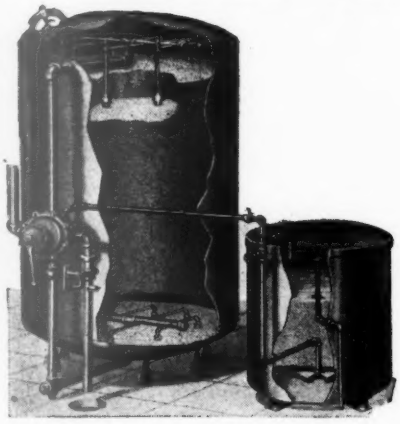
Leland I. Doan, vice president and director of sales of The Dow Chemical Company, has announced the appointment of Donald Williams as general sales manager and Donald K. Ballman as assistant general sales manager.

Williams, who has been assistant general sales manager since 1933, joined the Dow sales staff in 1924 as a member of the insecticides division. He subsequently transferred to Dowflake sales and was in charge of that division from 1929 until 1933. He graduated from Pennsylvania State College in 1916, and before coming to Dow was connected with the extension department of Michigan State College.

Ballman graduated from Indiana University in 1929 and, after working with the Sears Cabinet Company of Indianapolis for several years, returned to the university in 1934 for his master's degree in chemistry. In the fall of 1935 he went to Midland and after completing the Dow training course was placed in insecticide sales where he was largely responsible for the market development of the Dowicide line of fungicides and wood preservatives. In 1943 the technical service and development division was organized under his managership, where he has served until his present promotion.

Doan, who now assumes the position of director of sales, has been general sales manager for the last 16 years, having begun his career with Dow in 1917. He has been a vice president of the company since 1936 and secretary since 1941. He also holds several offices and directorships in various Dow subsidiaries.

ELIMINATES HARD WATER SCALE DEPOSITS



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ELGIN WATER SOFTENER

gives up to 44% more soft water

This is no time to put up with troublesome hard water lime and scale deposits. The remarkable new Elgin Water Softener turns hard water soft — keeps equipment clean and efficient — eliminates the delay and expense of shut-downs for cleaning and repairs. Prevents loss of zeolite—cuts salt cost.

HOW TO STEP UP CAPACITY OF EXISTING WATER SOFTENERS

The Double Check Manifold arrangement can be installed quickly in any make water softener. This, with

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when required will greatly increase soft water output and efficiency.

WATER TREATING CHEMICALS

For Boiler Feedwater

Specially formulated for your specific needs. Prevents scale formation and corrosion.

For Hot and Cold Water Systems

To prevent corrosion and "red water" troubles; to prevent lime and scale deposits.

Write for new bulletin 603

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SOFTENERS ★ FILTERS ★ WATER TREATMENT ★ BOILER WATER CONDITIONING

ENGINEER-SURVEYOR (Foreign) to make surveys on concessions from government to establish boundaries, lot selections, rights of way, etc. Must speak fluent Spanish and be capable of directing field party composed of natives. Major oil company. Apply P. O. Box 2819, Dallas, Texas.

Ohio management changes

Changes in the management ranks of The Ohio Oil Company have been announced by President O. D. Donnell at Findlay, Ohio.

Effective September 1, C. L. Fleming retired as a director, vice president, and manager of the refining and marketing department under the company's retirement plan, after having completed 47 years of continuous service with the company.

C. Z. Hardwick

W. B. Emery

Wilson B. Emery, now vice president and manager of production, has been elected a member of the board of directors to fill the vacancy caused by Fleming's retirement. C. Z. Hardwick, who has been assistant manager of the refining and marketing department since 1934, has been elected a vice president and will succeed Fleming as manager of the refining and marketing department.

Fleming's retirement terminates a unique career that began as an office boy in the company's Oil City, Pennsylvania, office on June 10, 1898. Transferred to Findlay two years later as a stenographer in the executive offices, he served in various secretarial capacities until January 1, 1915, when he was made assistant secretary of the company. He was elected secretary in May, 1918, and on February 7, 1927, was elected to the board of directors. The following year he resigned as secretary to become a vice president of the company. From 1927 until the early part of 1934, Fleming was in charge of crude oil sales. In the latter year he was placed in direct charge of the company's refining and marketing operations.

At a meeting of the board of directors of the company, President Donnell, on behalf of the board, complimented Fleming on his achievements, expressed appreciation for his many years of faithful service, and presented him with a diamond mounted gold service pin in commemoration of the completion of his 47 years of continuous service.

Richmond board chairman

Election of R. C. Stoner as chairman of the board of the Richmond Petroleum Company of California has been announced. Norman Hardy was elected president. Richmond, a Standard of California subsidiary, is engaged in exploration in Venezuela and Colombia.

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BY 7 YEARS EXPERIENCE

RECTORSEAL has been used by the Industry for seven years to prevent leaks in threaded, gasket and coupled connections. They have come to depend on this high quality chemical compound to assure leak-proof connections on lines handling all petroleum products, salt water, dilute acids and steam up to 400 degrees F. Constant laboratory research keeps RECTORSEAL abreast of the needs of the Industry. RECTORSEAL is available at practically all Supply Stores. Ask for it by name.

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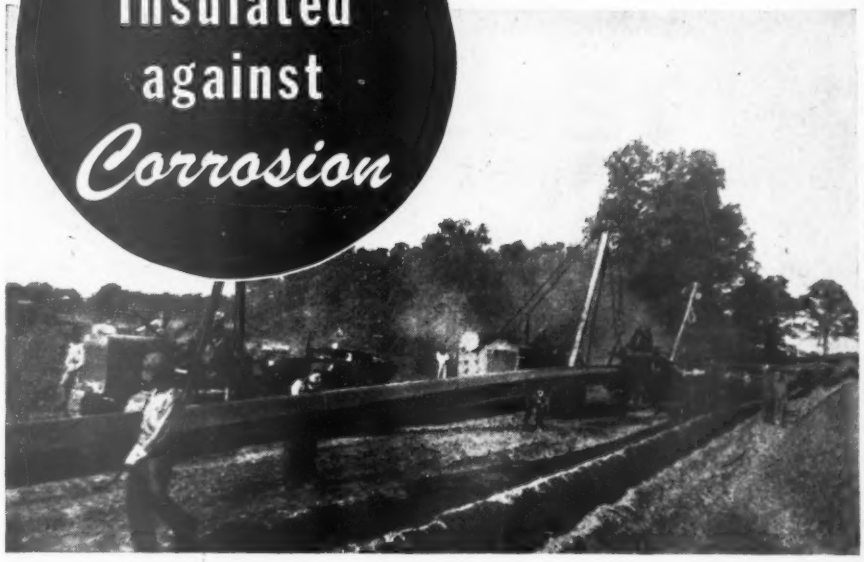
RECTORSEAL
THE POSITIVE LEAK PREVENTER

Completely Insulated against Corrosion



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Send for your copy of this new 20-page booklet describing Reilly Protective Coatings for metal, brick, cement and wood surfaces.

● Reilly Primer and Enamel provide a pipe coating that completely insulates the pipe against destructive elements—preventing all corrosive agencies from coming in contact with the metal. The coating is so regulated in its properties that it will withstand temperatures as low as minus 20°F without cracking or checking, and as high as 160°F without flow or sag. Reilly Enamel is manufactured in two standard grades—also to meet special requirements. It is readily applied—at the mill or in the field—by any of the standard methods.

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JENSON Units improve any well!

Twenty-five years of "know how" enables us to build a pumping unit likely to make any well more profitable and satisfactory. There is nothing revolutionary in the appearance of a JENSEN Unit, but there sure is a lot of difference in a JENSEN-equipped well.

JENSEN Owners, and field men who look after JENSEN Units are much more enthusiastic than we can afford to be in our advertising. Ask them. See your JENSEN dealer. Consult Composite Catalog pages 1473-6.

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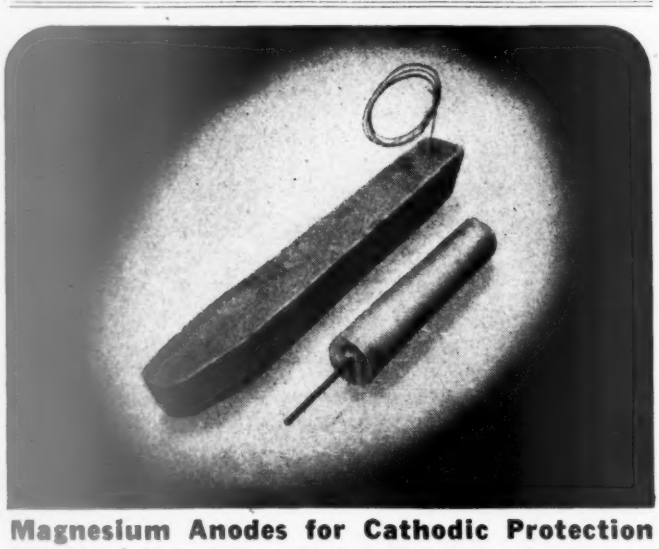

Magnesium Anodes for Cathodic Protection

Corrosion of pipelines and other buried metal structures may be greatly retarded by use of Magnesium Anodes. When properly installed—taking into account variations in soil conditions, location and frequency of anodes—Magnesium Anodes can provide maximum protection with attractive cost advantages. Federated magnesium alloy anodes with cast-in iron lead wires are available in two shapes—

4" diameter x 18" long—weight about 12#
4¼" x 4¼" x 3' long—weight about 40#

(Can be made in other shapes to suit your requirements—write for further information.)

FMD
Federated
METALS DIVISION
AMERICAN SMELTING and REFINING COMPANY
120 BROADWAY, NEW YORK (5) N. Y.
Nation-wide service with offices in principal cities

Lt. Col. A. B. Stevens on leave

Lt. Col. Stevens

Lieutenant-Colonel Albert B. Stevens has returned to College Station, Texas, to begin a 60-day leave, after which he will be released from the army in which he has served since January, 1942. Colonel Stevens is on leave from Texas A & M and holds the position of professor of petroleum engineering. He has been a member of the A & M faculty since 1934.

Called to active duty in January of 1942, Colonel Stevens went overseas in March, 1944. Most of his service overseas was with the military pipe line service as chief of the construction branch, his principal task being to provide engineering supervision in the construction of pipe lines supplying petroleum to the armed forces.

Denies Ohio plant for sale

The Cooper-Bessemer Corporation, manufacturers of diesel and gas engines and compressors, has denied that its Mount Vernon, Ohio, plant is up for sale by the government as surplus property, which was erroneously reported in a statement released by the Reconstruction Finance Corporation.

"The only part of the company's Ohio plant that is owned by the government is a core shop that the government built on property deeded to it by the company two years ago," Z. E. Taylor, secretary and treasurer, declared. All other buildings that are part of the plant are owned by the company, he said.

The core shop is a very small part of the company's plant there and was added so that government orders for diesel engines and compressor units for use during the war could be facilitated, Taylor stated.

The Mount Vernon plant was one of a large number of Ohio plants listed as being up for sale by the government as surplus buildings owned by it.

Crane board chairman dies

After being with Crane Company for 53 years, John B. Berryman, chairman of its board of directors since 1935, died in Chicago on August 10, at the age of 83.

Berryman was born and received his early education in Canada, going to Minneapolis in 1885 where he started as a bookkeeper in the plumbing supply company that later became Crane Company's Minneapolis branch. After a few years as manager of that branch, he was made manager of the company's newly created engineering sales department in Chicago.

In 1911, he became secretary of the company and the following year, upon the death of R. T. Crane, the founder, he was elected a director and third vice president. He served as a director from that time until his death. In 1914, he was advanced to first vice president, which position he held until his election to the presidency of the company in 1932. He served in this capacity during the trying years of the depression and then in 1935 relinquished active management to younger men.

Funeral services were held at St. Andrews Episcopal Church, Downers Grove, Illinois, on August 14, and he was buried near the country home on the edge of that suburb where he had lived for many years.

Bourne made sales manager

The appointment of Henry A. Bourne as sales manager for Republic Steel Corporation in the Tulsa, Oklahoma, district is announced by J. M. Schlendorf, vice president in charge of sales.

Borne joined Republic in 1943 as a salesman in the Tulsa district. Prior to that, he was district sales manager in Houston for the A. O. Smith Corporation of Milwaukee.

He was born in Brooklyn, New York, attended high school in Westfield, New Jersey, and the Wharton School of Business and Finance at the University of Pennsylvania.

Bourne was a petty officer in World War I, and spent five years in Venezuela in the oil business.

He succeeds the late Hoyle Jones.

Houdry experts to Russia

Eugene J. Houdry, inventor of catalytic cracking and president of the Houdry Process Corporation, and Arthur V. Danner, executive vice president of the corporation, with several associates, have arrived in Moscow to discuss the operation of Houdry catalytic cracking facilities being installed in Russia. The trip is being made at the request of the Russian Government with the sanction of the U. S. Department of State.

In order to provide aviation gasoline facilities in the USSR, a special commission of Russian petroleum experts came to the United States in 1942. Eight Houdry catalytic cracking units were ordered for Russia under lend lease arrangements with the United States. Construction of an approximately 25,000-bbl.-per-day plant is nearing completion. Houdry and his group plan to discuss the efficient operation of these units and to conduct a general discussion of refining methods.

Chiksan representative

Chiksan Company, manufacturers of Chiksan ball-bearing swivels, Brea, California, announces the appointment of Well Equipment Manufacturing Corporation, Houston, Texas, as exclusive Chicksan representatives for the states of Texas, Oklahoma, and Kansas and portions of Mississippi, Arkansas, and New Mexico.

Well Equipment Manufacturing Corporation will handle the distribution of Chicksan ball-bearing swivels to the petroleum industry and to industry in general in this area. The members of the "Weco" organization are thoroughly experienced in this line as Well Equipment Manufacturing Corporation has already served successively for a number of years as Chicksan distributor in portions of the larger territory that it now covers.

Hedden named by Vortox

Announcement of appointment of N. B. Hedden as sales representative for the eastern and central states, has just been made by the Vortox Company of Claremont, California. His headquarters will be at the Vortox office in Detroit following an extended visit at the laboratories and main offices in California.

Prior to joining Vortox, Hedden was in charge of the tractor test program of the Oliver Corporation at Phoenix, Arizona, where the performance and efficiency of heavy duty air cleaners were important factors. Previously, he was associated for more than 14 years with the Ethyl Corporation, following graduation from Purdue University.

Advertising manager Fairbanks-Morse

Lewis A. (Lew) Harlow, who recently took over the post of manager of the advertising division of Fairbanks, Morse and Company, brings a wealth of talents and training to his new job. In a manner of speaking, Harlow began training for the position at the early age of 14 when he was editor, typesetter, and printer of his class paper at Milton Academy. Later, still pursuing the course he seemed destined to follow, he was made editor of the school paper in 1919, his last year.

Incidentally, the Milton Academy paper was an outstanding paper of its type and carried considerable national advertising.

From Milton Academy Harlow entered Harvard University and graduated with honors in 1922.

Although only 21 years old when he was graduated, "Lew" Harlow gave immediate evidence that he didn't intend to stand still and wait for things to come his way. Shortly after his graduation he organized his own business—a publishing house for instruction manuals and textbooks for public schools.

Sometime later, during its formative years, he also became interested in radio as an entertainment and commercial medium. Recognizing the possibilities of the then infant industry, he spent a number of years producing and managing programs, in addition to managing his publishing interests. During this period he acquired a broad knowledge of the radio field.

In 1943 he joined Fairbanks-Morse as assistant advertising manager, and, until his recent advancement to the position of manager, helped supervise the many and varied advertising activities of the company.

★ *New Cannon 600-amp. Heavy Duty Plug*

EVERY OILFIELD PUMPING ENGINE NEEDS THIS MODERN CONNECTOR

The field service man shown in the photo at right is saving his company time and money by using a Cannon Plug to connect the power from a battery on the service truck to the pumping engine for starting purposes.

Why? Starting is quick and safe; special switching device avoids "arcing"; neither batteries (on the engine) nor generators are required. These savings alone will pay for connector installation many times over. Ask for Cannon Type GB-3-21-CFS Plug and GB-3-34-CDS Receptacle. Write Dept. A-119, Cannon Electric Development Company, 3209 Humboldt St., Los Angeles 31, Calif.

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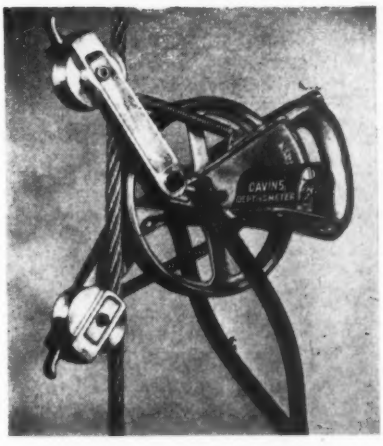
Cannon 1B-6045

The CAVINS DEPTHOMETER



For quick and accurate well measurements when running bailers, swabs, and similar tools on a sand line. This device is rapidly being adopted by many producers as standard equipment for well-pulling crews.

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Pacific Personalities

DICK SNEDDON

Now that the war jitters are over and even an oil man can get gasoline, one of the items that looms large in the postwar plans of the West Coast petroleum operator is a fishing trip. Drillers, who normally hate a fishing job, are nonetheless busily engaged in assembling the diverse accoutrements of the Waltonian art, and if all the threats so far made are successfully carried out, there soon won't be a minnow left in any stream between San Diego and the Canadian border.

●

Some of the boys just couldn't wait for V-J Day. **Tommy Atkinson** and **John Hills** of the General Petroleum Corporation joined forces with engineers **Jim Moon** and **John De Hetre** recently on an expedition to the High Sierras. They took along **Jerome,** another scion of the House of De Hetre, to arbitrate any deadlocks that might develop. The transportation medium consisted of an ancient Model T that emitted hissing steam from every aperture. It made the round trip successfully, nevertheless, not only with the five stalwarts, but in addition with John Hills' Gladstone bag, which is undoubtedly the biggest bag that Gladstone ever made. Photos show that the group caught some fish, but in these days of trick photography, at which Jim Moon is a master, well—

●

It's good news that **Lawton "Beck" Beckwith,** the Union Oil Company research supervisor, has left San Pedro hospital and is now recuperating at his home after a tough siege with a ruptured appendix. Beck is the company's electronic wizard. They say he is a veritable encyclopedia on the subject. Oh, yeah! A funny encyclopedia—with no appendix!

●

Recently had a call from our good friend **Bill Goertz** of Axelson Manufacturing Company, just returned from the Mayo Clinic at Rochester and confident that from now on his back is going to behave like a gentlemanly back. In case you don't know, Bill is one of these statistically minded lads, who like to lay things end to end—especially dominos.

●

Paul Huggins of Western Gulf, when not officiating as chairman of the Paloma Operators, is wont occasionally to take his best stance out to one of the local golf courses and trounce the good earth in no uncertain manner. He is said to have an extremely powerful southpaw swing, which explains why he usually drives the ball so far into the ground.

●

Back from an extended stay in Wyoming and Montana is G.P.'s **Carroll Wagner,** a man of substance in geological circles, and we don't mean to imply that geologists go around in circles. Carroll still likes California summers best, but is willing to concede that Montana has Great Falls.

●

Another geologist back on the local scene is Continental's **Glenn Bowes,** also president of the A.A.P.G. out thisaway, who has just completed a two weeks' furlough. Glenn says the vacation was all right, but after all there is nothing like the feel of a good desk under your feet.

●

And **Walt Greenfield,** the Signal Oil and Gas impresario, is resting his thorax after a strenuous day of harmonizing at the Petroleum Production Pioneers barbecue. It is reported that representatives of several local banks are studying Walt's technique in an effort to find out how he manages to hold his notes so long.

The recent elevation of **Herb Eggleston** reminds us that we once promoted a saw-playing contest between Herb and Cy **Rubel** that created a minor sensation among the oil fraternity of Los Angeles. The opera house was jammed to the door on the night of the big event and great excitement prevailed as the virtuosos flexed their bows before the opening joust. When it was over, and before the judges had reached a decision, Frank Morgan threw in an extra challenge and at the same time threw the place into an uproar. His challenge accepted, he promptly produced an old rusty saw from a decrepit violin case, smacked it once or twice with a mallet, and, in a frame-up that rocked the musical world to its very foundation, ran off with the grand prize.

●

At a recent outing we observed **Jim Gregory,** Shell's Southern California division mechanical engineer, fraternizing with **Elmer Decker,** the well known equestrian from Long Beach, and both enjoying themselves no end. Seems only yesterday that Jim was just another outstanding school student. Now he carries as much weight in the industry as a Martin-Decker indicator.

●

Art Wilson, Standard's maintenance supe, is one of the oil industry's most conscientious civic workers. As a matter of fact, when he lived down at Huntington Beach, they thought so much of him that every time he had a headache, the entire city council took an aspirin.

●

A profound student of botany is **Ben Moeller,** who has been instrumental in developing some highly pertinent data on the flora of California. Particularly interesting is his suggestion that the ideal gift for irrepressible after-dinner speakers is a bouquet of California poppies. These beautiful blossoms always shut up at sundown.

●

And, concluding, **Ralph Marshall** says, "One nice thing about being a driller is that you don't have to begin at the bottom."

Opens Atlanta office

The Chicago Bridge and Iron Company opened a sales office in Atlanta, Georgia, on September 1. It is in the Healey Building. H. F. Stearns is in charge of the new office.

Heads engineering for GE

Harry A. Winne, vice president in charge of engineering for the General Electric Company's apparatus department, has been appointed vice president in charge of engineering policy for the entire company, effective September 1, by Charles E. Wilson, president of General Electric.

Ernest E. Johnson, assistant engineer of the aeronautics and marine engineering division, has been named to succeed Winne by R. C. Muir, vice president, general manager of the apparatus department.

In assuming his new duties, Winne becomes a member of the president's staff. His headquarters will be in Schenectady. As chairman of the engineering council, Winne will coordinate the engineering, scientific, and research projects of all departments and all laboratories of the company. He will also be responsible for company policy and activities in connection with standards and the coordination of matters relating to recruiting, education, and transferring between company units of all engineering personnel.

Bailey Meter sales executives

The appointment of W. E. Dueringer as assistant sales manager and H. E. Weaver as proposition department manager has been announced by H. M. Hammond, general sales manager of Bailey Meter Company, Cleveland 10, Ohio.

Both Dueringer, who is a graduate of the University of Illinois, and Weaver, who is a graduate of Johns Hopkins University, have been associated with Bailey Meter Company for more than 25 years in various engineering and sales capacities.

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Are you spending time and labor, losing productive hours, running up maintenance costs *because of frequent need for repacking?* Some operations require repacking service every few months, some need repacking every few weeks. That is, with ordinary packing.

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TUBE CLEANERS & EXPANDERS

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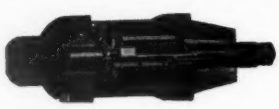
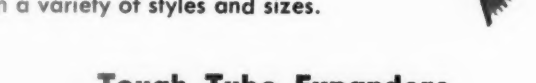


Airetool Tube Cleaners are driven by a power seal motor that develops 28% more power, and can be loaded down to 50 rpm. and keep right on going. Has slip fit construction for easy maintenance. For tube sizes ½" to 24" I.D., straight or curved.

New Form Cutters

New Form Cutters are made of special heat treated alloy steels for prolonged usage. They are designed to remove severe deposits in tubes quickly and efficiently without tracking. Made in a variety of styles and sizes.

Tough Tube Expanders



Airetool Tube Expanders are made of heat treated alloy steels for endurance. No tube expanding job is too tough for them. Many styles and sizes.

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Book Reviews

● **The Magic Powder,** *by Earl J. Hadley. G. P. Putnám's Sons, New York. Pages, 382. Price, $3.50.*

The Magic Powder tells the story of the cement industry as seen through the Universal Atlas Company, largest cement manufacturer. It translates the scientific and technical aspects of the industry into terms understandable by the average man. It describes the origin and growth of various processes that have furthered the industry. Both accurate and comprehensive, it is a story of the part cement and concrete have played in every activity of engineering and architecture.

● **American Malleable Iron, A Handbook,** *Malleable Founders' Society. The Rumford Press, Concord, New Hampshire, Pages, 367.*

Written by many eminent authors, this handbook is an attempt to assemble and edit published and other available data on malleable iron. It is designed to be of use to the student, teacher, metallurgist, customer, government agency, Army and Navy, and any others interested in the subject. It includes material on the manufacture and proper use of malleable iron in ever-increasing fields of service.

● **Industrial Plastics,** *by Herbert R. Simonds. Pitman Publishing Corporation, 2 West 45th St., New York 19, N. Y. Pages, 396. Price, $5.00.*

Comprehensive but concise, Industrial Plastics, is the third edition revised to include three new materials in the American plastic industry. It includes many suggestions for new applications and markets. Both a practical engineer and a technical writer, the author has succeeded in presenting his subject matter in a way useful both to industry and student. It is an indispensable source of information for the user and prospective user of industrial and structural materials.

● **Training for Supervision in Industry,** *by George H. Fern. McGraw-Hill Book Company, Inc., New York, N. Y. Pages, 188. Price, $2.00.*

This book is a complete guide on the training of personnel for industry. It presents suggestions to help the supervisor in up-grading and self-improvement and to aid him in his training program. It explains the conference method and recommends it for accomplishing training. It deals specifically with such problems as maintaining mental health in industry, handling problems of women workers, promoting safety, training new workers and disciplinary problems.

● **Texas Looks Ahead, Volume I, The Resources of Texas,** *by staff members of the University of Texas, University of Texas Publications, Austin. Pages, 365. Price, $1.*

The first of two volumes to be published dealing with the potential developments in Texas in the postwar period, this publication makes a comprehensive analysis of the resources of the state and discusses the uses of these resources in the future. Covering a broad field, the book lists and discusses the various types of Texas resources, including agriculture, oil and gas, petroleum and synthetics, natural gas and gasoline, coal, lignite, iron, and many others. It explains how these may be utilized to the greatest possible good of the nation in the postwar era. Included are nearly 100 pages of information and facts dealing with the petroleum and allied industries. Various University of Texas staff members have written the different chapters. Each author is an authority within his field. The book is recommended by the publishers to the people of Texas and all others who are interested in the future development of the state.

Opens Dallas office

Cook Electric Company, Chicago, Illinois, has recently opened a branch office at 909 Cotton Exchange Building, Dallas, Texas. William E. Jarnigan is in charge as Texas representative. The telephone number is Central -7305.

Cook Electric makes MagniLastic expansion joints and Transpyro heat convectors for the oil industry.

Executive sales director

The appointment of Norman Wunderlich, long prominent in the radio industry, as executive sales director of radio equipment and allied products, has been announced by the Federal Telephone and Radio Corporation, Newark, New Jersey, manufacturing associate of the International Telephone and Telegraph Corporation. He comes to Federal from the Galvin Manufacturing Corporation, where he was manager of the communications and electronic division.

N. Wunderlich

In his new position, Wunderlich heads up six sales sections embracing broadcast equipment, industrial electronics, rectifier equipment, aerial navigation, mobile radio equipment, and components. Some of the equipments and products included under these general classifications are FM, AM and Television broadcast, pulse time modulation, two way emergency radio, point-to-point, induction and dielectric heating, instrument landing systems, direction finders, transformers, high frequency cable, quartz crystals and transmitting, rectifier and industrial power tubes.

Previous to his association with Galvin, which extended over a period of five years, Wunderlich operated the Rauland Corporation, and some time prior to that was director of engineering and research for the Victor Talking Machine Company and later RCA-Victor. Wunderlich also has been prominent in radio developments, being responsible for the Wunderlich tube, the first dual purpose tube, and he holds original patents on amplifier automatic volume control and coaxial antennas.

Control division reorganized

Four men have been named to head newly organized sections in General Electric's control division, new name of the company's former industrial control division, by Karl H. Runkle, manager of the G-E industrial divisions.

William M. Anthony is manager sales of the industry control section, Edward S. Bush is appointed manager sales of the appliance and aircraft control section, S. V. W. Dockstader has been named manager sales of the general purpose control section, and William J. Stock is in charge of the marketing and promotion section.

This reorganization has been made so that the control division can handle more efficiently the increased volume and variety of control business expected in the postwar period.

Already in existence in the division is the fifth section to make up the control group, the electronic control section, with A. E. Bailey, Jr., manager sales. K. R. Van Tassel is manager of the newly named control division, and R. S. Glenn is manager sales.

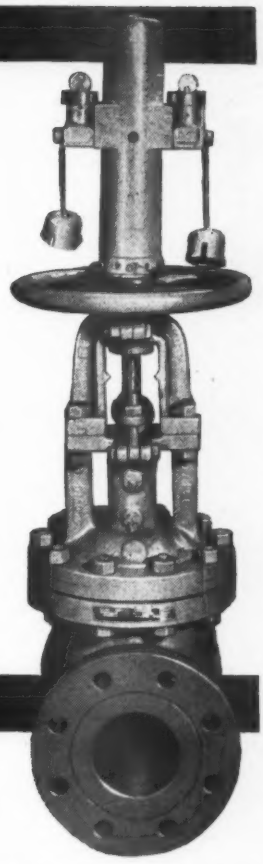
Anthony, a native of Newark, New Jersey, joined General Electric in 1923 at Bloomfield, New Jersey. He received an engineering degree at Newark Tech in 1929, and, after a few months as a student engineer on the company's test course at Schenectady, entered the industrial control division.

Bush, born in Atco, New Jersey, became a General Electric employe in 1926 as a student engineer on the test course at Bloomfield. In 1928 he received a bachelor of science degree in electrical engineering from Newark College of Engineering. He has been in the industrial control division at Schenectady since 1930.

A native of Pattersonville, New York, Dockstader joined the company in 1903 at Schenectady, and the following year was a testing engineer. In 1910 he transferred to the supply department, and through changes in the organization setup subsequently became associated with the industrial control division.

After his graduation from Purdue University in 1916 with a bachelor of science degree in electrical engineering, Stock came to General Electric in Schenectady as a student engineer on the test course. In 1917 he joined a group that is now the control division, where he has remained up to the present time. Stock was born in Elkhart, Indiana.

MECHANICAL GUARDIANS FOR ALL KINDS OF PIPE LINES



In chemical industries, synthetic rubber plants, oil refineries . . . any plant, piping precious or potentially hazardous fluids . . . a mistake, whether unintentional or deliberate, in adjusting a pipe-line valve can prove both dangerous and costly. But prevention of these human errors is easy and infallible with BENDIX-CORY* SAFETY INTERLOCKS . . . the locks that say "No!" to unauthorized handling of your valves.

The BENDIX-CORY SAFETY INTERLOCK illustrated gives absolute control over the opening and closing of the valve to which it is attached . . . and, by use of an interlock key, can also control the position of this valve in relation to any number of other valves. The unit is wholly mechanical, and fully adjustable to compensate for valve wear—one of a number of interlocks specially designed for valve protection.

BENDIX-CORY SAFETY INTERLOCKS are dependable guardians for your pipe lines. Write for full information.

*TRADE-MARK

CHECK THESE FEATURES

- ✓ Interlocks stem valves 2" to 8". Other interlocks for globe, lead and porcelain valves.
- ✓ Absolute control of valve opening and closing under all conditions.
- ✓ Positions valve in relation to other valves.
- ✓ Ample strength characteristics.
- ✓ Indoor or outdoor installation without removing valve from service.
- ✓ Fully mechanical. No electric circuit.
- ✓ Position indicator (not shown) shows valve open or closed.
- ✓ Adjustable compensation for valve wear.

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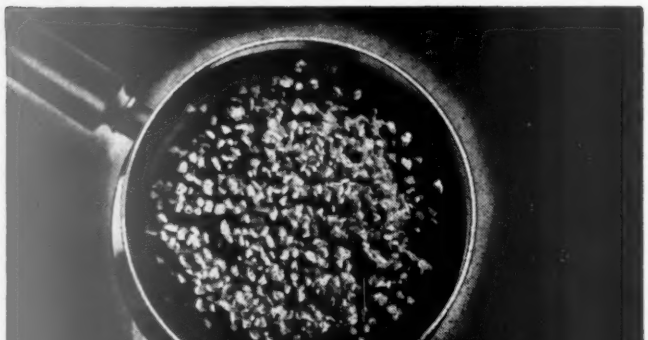

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Those tiny porous particles that have the strange power of adsorption are truly "Mighty Mites." By virtue of its intricate physical structure as well as its chemical composition, an adsorbent will draw out from gases and liquids—even perhaps from within a solid mass—those components for which it has an attraction. Its capacity and selectivity may be almost beyond belief.

Adsorbents are used for economical and efficient removal of impurities or recovery of valuable compounds from dilute mixtures. In the production of such varying materials as lubricating oils, gasoline, penicillin, synthetic rubber, vitamins, paints and many chemicals, they are indispensable.

Floridin technicians have been studying the behavior of adsorbents for 35 years and the Floridin Company's products are adapted for a wide range of uses. If you have a problem of adsorption—dehydration—decolorization—catalysis, your inquiry will be welcomed.

Floridin
ADSORBENTS

FLORIDIN COMPANY, INC.
Room 54, 220 Liberty Street, Warren, Pa.

Lincoln Electric opens new office

The Lincoln Electric Company, manufacturers of arc welding equipment, announces the opening of a direct factory branch sales office in St. Louis, Missouri.

The new branch, under the direction of B. J. Brugge as welding engineer and district manager of sales and service, will be at 4427 Manchester Avenue, with telephone number Newsteak 6516.

B. J. Brugge

Brugge has been associated with The Lincoln Electric Company since 1931. He is a graduate of Purdue University and began his career in arc welding with two years in research laboratories of the company. In 1935 he was granted a leave of absence to assist the application of electric welding in the Near East. Serving in the capacity of welding superintendent for the Anglo-Iranian Oil Company, he spent two years at Iran, Persia, supervising welding operations in the construction of refineries and pipe lines. He directed the training of many Persians in the art of welding and increased the Anglo-Iranian Company's welding forces from 30 to 120 arc welders.

After his work in Persian oil fields, Brugge spent four months in the British Isles as welding consulting engineer for British and Scottish firms.

During the early years of the war, Brugge redesigned and constructed the Army's first all welded medium tank at Rock Island Arsenal and helped develop armor plate welding, working with the Army Ordnance at the Aberdeen Proving Grounds. He has also assisted the Navy and Maritime Commission with consulting services on shipwelding.

For the past year Brugge has served The Lincoln Electric Company in the Detroit area in assisting firms in the design and fabrication of both war and postwar products.

Patterson-Ballagh expands

In an effort to keep abreast of demands by the oil industry, Patterson-Ballagh is completely reorganizing plant layout for increased efficiency and has added 15 new presses, which will increase production 75 per cent.

J. C. Ballagh, secretary, states, "During the war years our equipment has been forced to produce day and night to take care of oil field requirements. In an effort to maintain top quality production of Patterson-Ballagh protectors, pipe wipers, wire line guides, and other oil field specialties, a complete modernizing program is now in effect that will reflect in even better service."

The Patterson-Ballagh plant in Los Angeles is one of the largest and most modern rubber plants in the west devoted to oil well specialties. Among the many products used throughout the oil fields are protectors, stabilizers, pipe wipers, wire line guides, dead line stabilizers, mud guns, wire line wipers, and traveling block bumpers. This equipment is either made of or incorporates PBX synthetic rubber especially developed by Patterson-Ballagh.

Open export offices

R. J. "Bob" Eiche and T. G. Martin recently announced the opening of their new Export Offices in Suite 422, Petroleum Building, 714 West Olympic Boulevard, Los Angeles 15, California, where they will continue as heretofore to handle foreign sales for the following companies: The Cavins Company, Chiksan Company, Eason-Therolf Tool Company, Eastman Oil Well Survey Corporation, Hamer Oil Tool Company, Hopper Machine Works, Inc., Pacific Perforating Company, Web Wilson Oil Tools, and Well Equipment Manufacturing Company.

Bob Eiche has been in charge of the export business for many leading oil equipment manufacturers for more than 25 years, and Martin has been associated with him in this work during a considerable part of that time. Both men are well known among petroleum and equipment men in this and foreign countries.

Manager Tulsa office

A. C. Evans has been appointed manager of the Tulsa office, 706 McBirney Building, of Norvell-Wilder Supply Company.

Evans was with the National Supply Company from 1922 to 1944 in the Kansas and Oklahoma area, and in 1944 and 1945 with the Empire Oil Field Machinery Company at Tulsa. He will handle all oil company sales for the Oklahoma-Kansas area.

Veterans return to Standard

More than 93 per cent of its employes discharged from the armed services have returned to work for Standard Oil Company (New Jersey) and its affiliates, Frank W. Pierce, director, has revealed.

In addition, the company has hired approximately 2000 returned veterans who were not previously employed by it.

"One out of every seven Jersey Standard employes went away to war, a total of more than 8000," Pierce states. "Nearly a fifth have now been discharged from the services, and we feel particularly gratified that such an overwhelming percentage of this number have come back with us."

In each case of a returning veteran, Pierce said, either his old job or another comparable to it is immediately available to him. In addition, the company interviews each to learn what if any added skills and capabilities he acquired while in service, and these are taken into consideration in putting him on an available better job.

The company's program also embraces a specific policy for returning disabled veterans, providing training to equip them, if possible, for an available job that he can perform safely. In the event a disabled veteran cannot do any work, the company's sick benefits apply and the firm aids him in getting government rehabilitation until he can return to work.

To receive AIC honor scroll

Dr. Donald Babcock Keyes, director of the office of production, research and development of the War Production Board, and head of the chemical engineering division of the University of Illinois, has been elected to receive the Honor Scroll of the American Institute of Chemists, which is awarded annually by the Institute to a man adjudged to have made outstanding contributions to the world in chemistry or chemical engineering. Presentation of the award will be made at a dinner, October 26, in Huyler's Restaurant, 310 South Michigan Avenue, Chicago, Illinois.

Dr. Keyes is thus honored in recognition of distinguished achievements in chemical engineering practice, in teaching, and in wartime service to the government. He has been on leave from the university during the war.

Graduating from the University of New Hampshire in 1913 with the degree of bachelor of science, Dr. Keyes received the master of arts degree from Columbia University the following year, and the Ph.D. degree from the University of California in 1917. After several years as a practicing chemical engineer and director of research, Dr. Keyes went to the University of Illinois in 1926 as professor of chemical engineering and head of the department.

He is a member of numerous scientific societies, among which are the American Chemical Society, the American Institute of Chemical Engineers (director), Fellow of the American Association for the Advancement of Science, and Fellow of the American Institute of Chemists.

He is co-author of "Chemical Engineering Manual."

Dr. H. R. Kraybill, director of research of the American Meat Institute, and chairman of the Chicago section of the American Institute of Chemists, will preside at the award dinner.

Dr. Gustav Egloff, Universal Oil Products Company, president of the American Institute of Chemists, will talk on "Keyes the Man."

Dr. Albert L. Elder, director of research, Corn Products Refining Company, will discuss, "Keyes and His Achievements."

Lawrence Brown, assistant director and reconversion officer of the chemicals bureau of the War Production Board, will talk on "Keyes and Chemicals During World War II."

The scroll will be presented by Dr. Kraybill.

ELECTRICITY

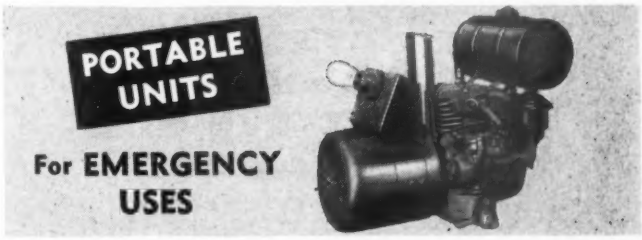
WHERE You Want It
WHEN You Want It

Model Shown: 6.25 KVA. 4-cylinder, gasoline. Water cooled. Push-button starter.

U. S. Electric Plants are engineered by men familiar with oil-field operating problems . . . and backed by over 50 years of manufacturing experience. Operating panel and instruments under weather-proof housing. Compact. Skids make handling easy. Complete line includes Gasoline units from 500 watts to 75 KW; Diesel units from 2 to 75 KW. AC and DC.

Model Shown: 1500 watts, 115 volts, AC. Automatic control. Single cylinder, air-cooled engine.

U. S. Automatic Electric Plants start when the first light is turned on . . . stop when the last light is turned off. Manual control units also available. Can be supplied for operation on natural gas. Simple, trouble-free design and rugged construction have made these units famous for reliability. 800 and 1500 watt models are the most popular for camp lighting.



Unit Shown: 600 watts, DC.

Wherever a breakdown occurs, get things going again in a hurry . . . no need to work in the dark if this compact 67-pound electric plant is kept handy! Other Portable units up to 15 KW. Write for literature.

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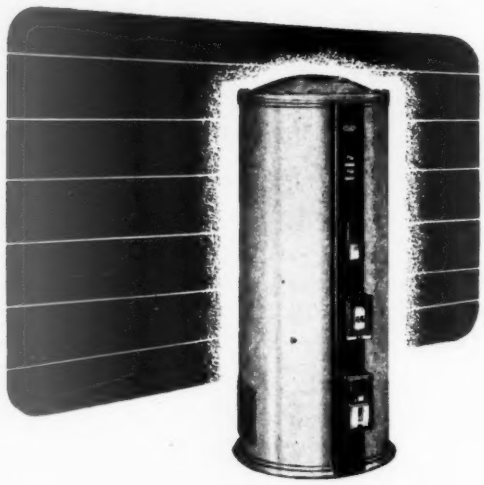

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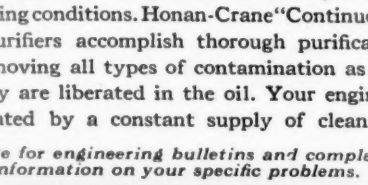

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W. B. duPont dies

William B. duPont, manager of the industrial division of the National Radiator Company, Johnstown, Pennsylvania, died in the Mercy Hospital in that city on August 9 after a short illness. He was 31 years old.

DuPont graduated from the Massachusetts Institute of Technology in 1936 and became associated with E. I. duPont de Nemours and Company at Richmond, Virginia. In 1939 he returned to MIT and obtained his master's degree in chemical engineering. Since then he had been with the National Radiator Company. He was a member of the American Society of Mechanical Engineers, the American Institude of Chemical Engineers, the Eastern States Blast Furnace and Coke Oven Association, and had been a member of the board of directors of the Johnstown Junior Chamber of Commerce.

Mr. du Pont is survived by his widow, Mary Aaron duPont, three sisters and two brothers. B. T. (Ermie) duPont, one of the surviving brothers, is manager of the plastic metals division of the National Radiator Company.

Expansion program announced

A $5,000,000 postwar research and production expansion program has been approved by the board of directors of the Allegheny Ludlum Steel Corporation, President Hiland G. Batcheller has announced.

An ultra-modern research laboratory and related experimental and pilot plant equipment will be built at company headquarters, Brackenridge, Pennsylvania, to intensify studies of the structure, melting, processing and further development of high alloy steels.

At the West Leechburg, Pennsylvania, plant will be constructed a cold rolling mill of latest design, for rolling stainless and silicon strip steels. It will add materially to the capacity of the plant and will bring new precision and uniformity of quality in the production of the special strip steels made there, it is stated.

"Work on these projects will get under way rapidly," said Batcheller, "and will provide additional employment for both communities. The joint research and production expansion program will enable the company to meet the needs of its postwar markets, with more and better alloy steels."

To visit UOP laboratories

The hydrocarbon research and development laboratories of Universal Oil Products Company at Riverside, a Chicago suburb, are one of the major points of interest that will be visited by a group of leaders in the industrial, financial, and education life of Mexico. The group will be guests of Chicago the first week in October.

The visitors will be conducted through this institution, which covers 27 acres. It includes chemical and physical laboratories and pilot plants as well as automotive engine laboratories for the testing and evaluation of automobile and aviation gasolines and diesel fuels.

Processes of major importance in peacetime refining and without which our flyers could not have been supplied with sufficient 100-octane gasoline, were invented and developed in these laboratories.

A number of other Chicagoland research establishments and industrial plants in various lines are to be included in the itinerary of the visitors.

They are to be delegates to a Mexican-American Conference on Industrial Research, sponsored by the Illinois Institute of Technology.

The purpose of the conference is to promote cultural and industrial relations between the two countries by showing the visitors fundamental and applied research at work in university laboratories, research foundations, in private industry, and in government-sponsored laboratories. While here the Mexicans will be guests of a committee of prominent Chicagoans. Dr. Gustav Egloff, of Universal Oil Products Company, is a member of the technical advisory committee for the conference.

Invitations sent to a number of distinguished Mexicans were received with enthusiasm. Twenty acceptances have already been received by the Illinois Institute of Technology.

Heads research laboratory

The establishment of a technical service and research laboratory by The Texas Company, Pacific Coast division, Producing Department, has been announced. William W. Robinson, Jr., formerly chief chemist of the company's gasoline division laboratory has been appointed chief chemist of the new organization with offices at Signal Hill, California.

W. W. Robinson

The new laboratory will carry out technical service and research activities connected with the drilling and production of petroleum and the processing of natural gas. Facilities are being enlarged by the erection of a research laboratory adjacent to existing buildings. The new building comprises seven research laboratories and a library.

Robinson entered the oil industry in 1923 as a chemist with the Chanslor-Canfield-Midway Oil Company at Torrance, California. In 1926 he was made chief chemist of the California Petroleum Corporation's natural gasoline laboratory, which in 1928 became a part of The Texas Company. In 1931 he became director of gas research of The Texas Company's Beacon Research laboratory, returning to California in 1933 to resume his former post in the gasoline division, which post he held up to the present change.

He is a member of the American Institute of Chemical Engineers, past president of the California Natural Gasoline Association, and a member of the California District Section of the API Central Committee on Drilling and Production practice.

Union of Canada sold

Purchase of the business and the physical assets of The Union Oil Company of Canada by The British American Oil Company, Ltd., has been announced by W. K. Whiteford, president of British American. Union Oil of Canada is a wholly-owned subsidiary of Union Oil Company of California and has been one of the large marketers of petroleum products in British Columbia and Alberta. In addition to its retail outlets and distribution, Union Oil has extensive marine bunkering and storage facilities in Vancouver Harbor.

In Vancouver to complete the deal with Union Oil Company officials was A. H. Miller, vice president in charge of sales of The British American Oil Company, and J. C. Hall, regional sales manager, western region, of B-A Oil.

Col. Verne Austin now

California oil men will be interested to learn of the promotion to full colonelcy of Verne Austin, for many years a member of the staff of the California Division of Oil and Gas in Bakersfield. A veteran of World War I, Col. Austin re-entered the service on February 19, 1941, and was immediately assigned to the 11th Cavalry. Two months later he was sent to the Army Industrial College, from which he was graduated in July and was given the "oil desk" in the Under Secretary of War's office in Washington, D. C. In February, 1942, he was sent to California and placed in charge of the Petroleum Unit, Western Materiel Command, U. S. Air Corps. It was this unit that established the guarding and anti-sabotage techniques for the plants supplying petroleum products to the Army and Navy. Later it was transferred to the 9th Service Command and its functions were closely integrated with the Facility Security Division of the Petroleum Administration for War.

In August, 1943, Major Austin was placed in charge of the 752nd Military Police Battalion, guarding the Tule Lake camp for Japanese. This was the period following the disturbances at that camp that were given a good deal of publicity. It was here also that he was promoted to lieutenant colonel. In February, 1945, after a score of German prisoners of war had escaped from their stockade at Papago Park, Arizona, Austin was transferred to that camp as officer in charge.

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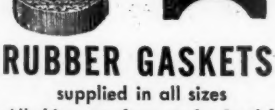

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Humble leases plant

Humble Oil and Refining Company has leased the Baytown Ordnance Works, which adjoins its Baytown refinery, from the United States Government. The lease is for an interim period, not to exceed 90 days, during which the company will use the ordnance works' facilities while final disposition of the plant is being determined.

Ordered shut down by the Army soon after Japan's surrender, the government-owned, Humble-operated Baytown Ordnance Works brought to a close a distinguished war production record that five times earned the Army-Navy "E" and Lieutenant General L. H. Campbell, Jr., then Chief of Ordnance, to say "Baytown Ordnance Works has maintained maximum production since its inception, producing the bulk of a most basic material of war during a period when no alternatives were possible, and without which the successful prosecution of the war would have been extremely uncertain at the least."

Until recent months, this plant produced substantially more than half of all the toluene for high explosives used by the United Nations in World War II. Completed in 1941, the Baytown Ordnance Works was the first to make toluene synthetically from petroleum, and the first shipment of the finished product was made 47 days before Pearl Harbor. It was designed to produce toluene at the rate of 30,000,000 gal. yearly, but by September, 1942, the production rate was double that amount; after October, 1942, the Baytown Ordnance Works was producing at the rate of approximately 70,000,000 gal. annually. This figure is more than twice as much toluene as could be made under the old processes available before the synthetic method of producing toluene from petroleum was perfected.

The outstanding performance of Baytown Ordnance Works enabled other toluene plants, which were built as wartime projects, to turn a part of their output into the 100-octane gasoline program, thus making possible increased supplies of that critical fuel.

Humble will use the facilities of Baytown Ordnance Works in the manufacture of commercial solvents.

Appointed Briggs distributor

Diesel Equipment Company, 308 South 2nd Street, Memphis, Tennessee, has been appointed distributor for Briggs Clarifier Company of Washington, D. C., and Bethesda, Maryland, manufacturers of industrial and marine oil filtration equipment. The territory assigned includes western Tennessee and northeastern Arkansas and portions of southeastern Missouri, southern Illinois, southern Indiana, and southern Kentucky.

Principal trading centers in this area include Nashville and Memphis, Tennessee; Evansville, Indiana, and Paducah, Kentucky.

Worthington Brown and William F. Fay who jointly own and manage the firm have had many years experience in the distribution and servicing of industrial products. They are intimately acquainted with the territory assigned to them and are fully equipped to give prompt and efficient service to present and future Briggs customers.

Named vice presidents

At a meeting of the board of directors A. G. Bussmann and L. D. Granger were elected vice presidents of the Wickwire Spencer Metallurgical Corporation.

Bussmann is also vice president in charge of sales of the Wickwire Spencer Steel Company. He has been associated with the company since 1930 in various sales and administrative positions, including general sales manager.

Granger, prominent steel metallurgist and engineer, has previously been assistant to the executive vice president of the Wickwire Spencer Metallurgical Corporaton. He is also vice president of and has long been associated with the American Wire Fabrics Corporation, another Wickwire Spencer subsidiary.

Bussman will continue to be at the Wickwire Spencer Steel Company's executive offices, 500 Fifth Avenue, New York 18, New York. Granger will be at the Wickwire Spencer Metallurgical Corporation's plant and offices, 260 Sherman Avenue, Newark 5, New Jersey.

Move advertising office

The A. P. Green Fire Brick Company has moved its advertising and public relations department from its general offices and plant at Mexico, Missouri, to St. Louis, with offices in the Railway Exchange Building. All company advertising is now being handled from that office.

Walker is Rodpak sales manager

Rodpak Manufacturing Company has announced the appointment of Ralph P. Walker as general sales manager.

Walker has been with General Petroleum Corporation for the last 12 years and has served as district sales manager for northern California and a part of Nevada for that organization.

A graduate of mechanical and industrial engineering at the University of Utah and at Columbia University in New York, he has had long experience in the supply of materials and machinery for industrial use. He has been engaged in refinery engineering, including the designing and constructing of "cracking" and reforming units. He has been sales manager for Paramount lubricants in Salt Lake.

Walker takes charge of Rodpak's sales as the company expands its operations. An increased sales force working from the head office in San Francisco and additional field representatives in various sections of the country, are part of the extension of activities planned by Rodpak.

Instrument educational conference

An educational conference on instrumentation sponsored by the Carnegie Institute of Technology and The Instrument Society of America has been arranged for October 16, 17, and 18.

The program will be divided into two parts. The first part will cover the requirements expected by industries and the second part will be devoted to present training in instrumentation.

The chairman of the committee is Dr. B. R. Teare, Jr., head of the Department of Electrical Engineering of the Carnegie Institute of Technology, Pittsburgh 13, Pennsylvania. Due to traveling requirements, the conference is limited to 50 and invitations will be sent to those in the order in which applications for attendance are received. Such applications should be made to Dr. Teare.

Opens New York office

The McGowan Pump Division of the Leyman Manufacturing Corporation, Cincinnati, Ohio, announces the opening of offices at 342 Madison Avenue, New York, Telephone Murray Hill 2-7195-7196. This office is managed by J. Arthur Moore who is well known among the petroleum, chemical, and industrial trade for his sound engineering ability. Complete technical sales information covering the application of McGowan Pumps will now be available from this New York office.

Buy Superior's Kettleman properties

Purchase of the Superior Oil Company properties in Kettleman Hills oil field has been announced by a group of operators having a substantial interest in the field. It is stated that this acquisition will make possible the operation of the field as a unit for the recovery of oil and gas in the manner that will best serve the national and public interests.

The purchasing companies include General Petroleum Corporation of California, Seaboard Oil Company of Delaware, Continental Oil Company, Shell Oil Company, Inc., Honolulu Oil Corporation, and Standard Oil Company of California.

Speaking of this purchase C. P. Watson, vice president of Seaboard Oil Company, who has been active in the negotiations, said, "This move will make possible closer cooperation in the operation of the entire field and we feel will result in substantially greater ultimate production."

The properties consist of the northeast quarter of Section 29, Township 21 South, Range 17 East, M.D.B. & M., Fresno County, California, a natural gas plant with a capacity of 40,000,000 cu. ft. per day and other production facilities.

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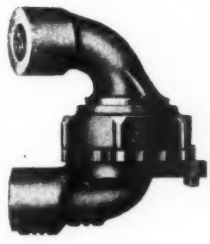

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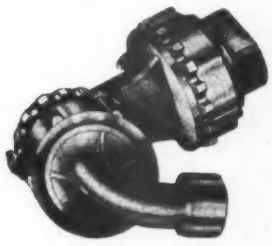

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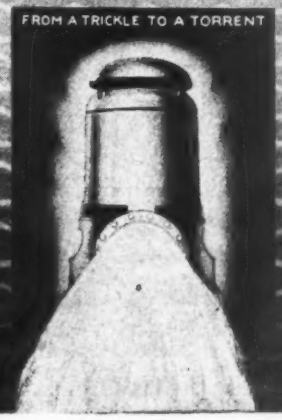

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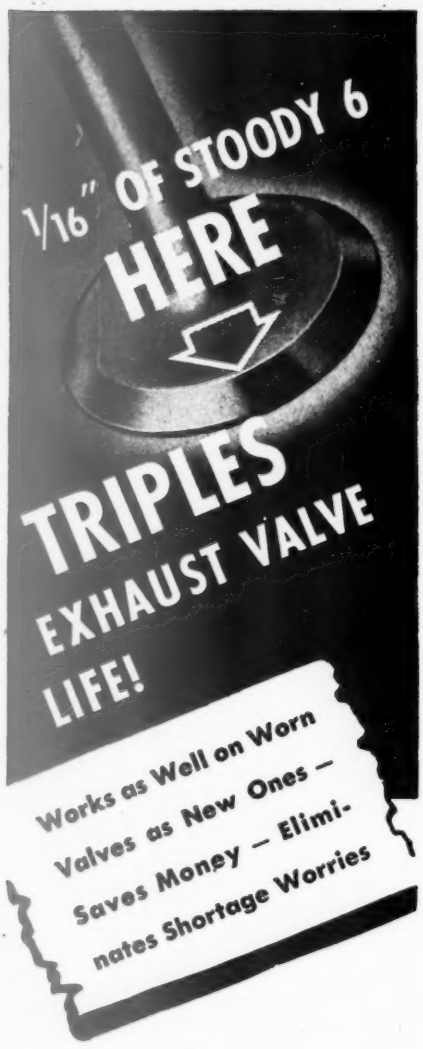
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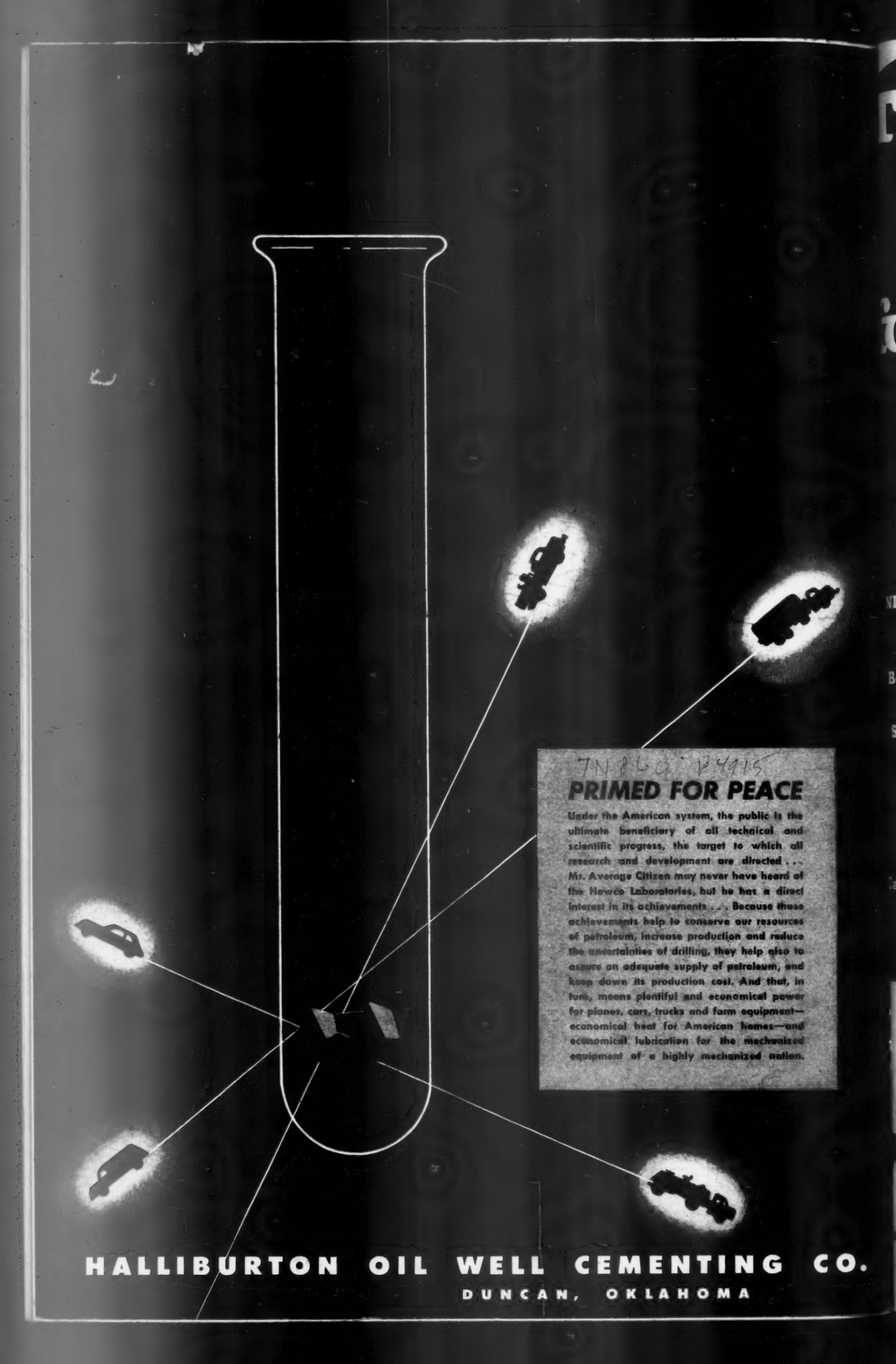
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Under the American system, the public is the ultimate beneficiary of all technical and scientific progress, the target to which all research and development are directed . . . Mr. Average Citizen may never have heard of the Hewco Laboratories, but he has a direct interest in its achievements . . . Because these achievements help to conserve our resources of petroleum, increase production and reduce the uncertainties of drilling, they help also to assure an adequate supply of petroleum, and keep down its production cost. And that, in turn, means plentiful and economical power for planes, cars, trucks and farm equipment—economical heat for American homes—and economical lubrication for the mechanized equipment of a highly mechanized nation.
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DUNCAN, OKLAHOMA

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for your job

Insist on Genuine

Swaged Nipples & Bull Plugs

Forged Steel & Wrought Iron Welding Reducers

NORRISIZED
Swaged Nipples & Bull Plugs
Forged Steel Seamless Welding Reducers
Also available in wrought iron.

NIPPLES — Tubing, Casing, Adaptor Perforated Pipe Nipples

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for reducing tubing or pipe

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W. C. NORRIS pioneered and introduced the exclusive NORRISIZING treatment that eliminates rust and corrosion. Prevents galling and seizing of threads, giving you products that remain bright and new throughout their useful life. To be sure of NORRISIZED Finish, insist on only the genuine W. C. NORRIS — look for the label.

Seamless Steel Substitute Collars For Reducing Tubing or Pipe

For over half a century, W. C. NORRIS and QUALITY have been synonymous in oil tools. Like the long famous NORRIS Swaged Nipples and Bull Plugs—used round the world, NORRIS Tubular products through Quality and Dependability on the job have won for themselves the highest endorsement of Petroleum Engineers, Superintendents and Production Men of long experience.

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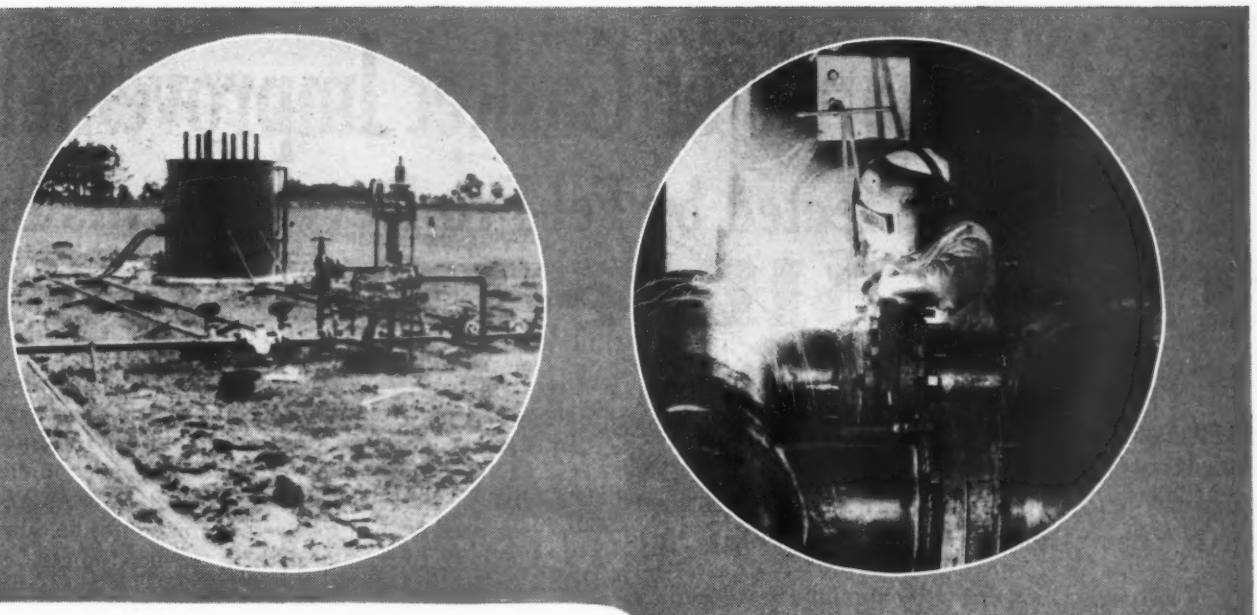
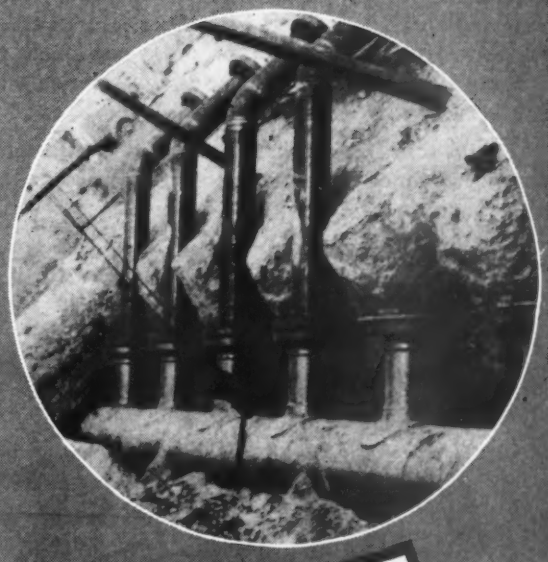
General Offices: St. Louis, Mo. Home Office and Factory: Erie, Pa., U. S. A. District Offices: Tulsa and Bartlesville, Okla.; Dallas and Houston, Texas; Mt. Pleasant, Mich.; Centralia, Ill.
BRANCH STORES AT ALL IMPORTANT PLACES IN THE OIL COUNTRY





Answers to your Problems From our Fabricating Shop

Our Machine, Welding and Pipe Assembly Plant has always been able to render quick, complete service in meeting many of the fabricating problems of our customers. Perhaps some of your requirements have been met with the nationally known products we stock, assembled into a special unit in the Maintenance fabricating shop. Whether it has been such things as the "Meco" two-stage heater and double-wing reducing regulator hookup, shown above; the header fabrication shown at the right; or other more complicated special jobs, these have been designed, fabricated and tested in our own shop. When you have a problem, call on us to help solve it.

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EQUIPMENT WITH ENGINEERING SERVICE

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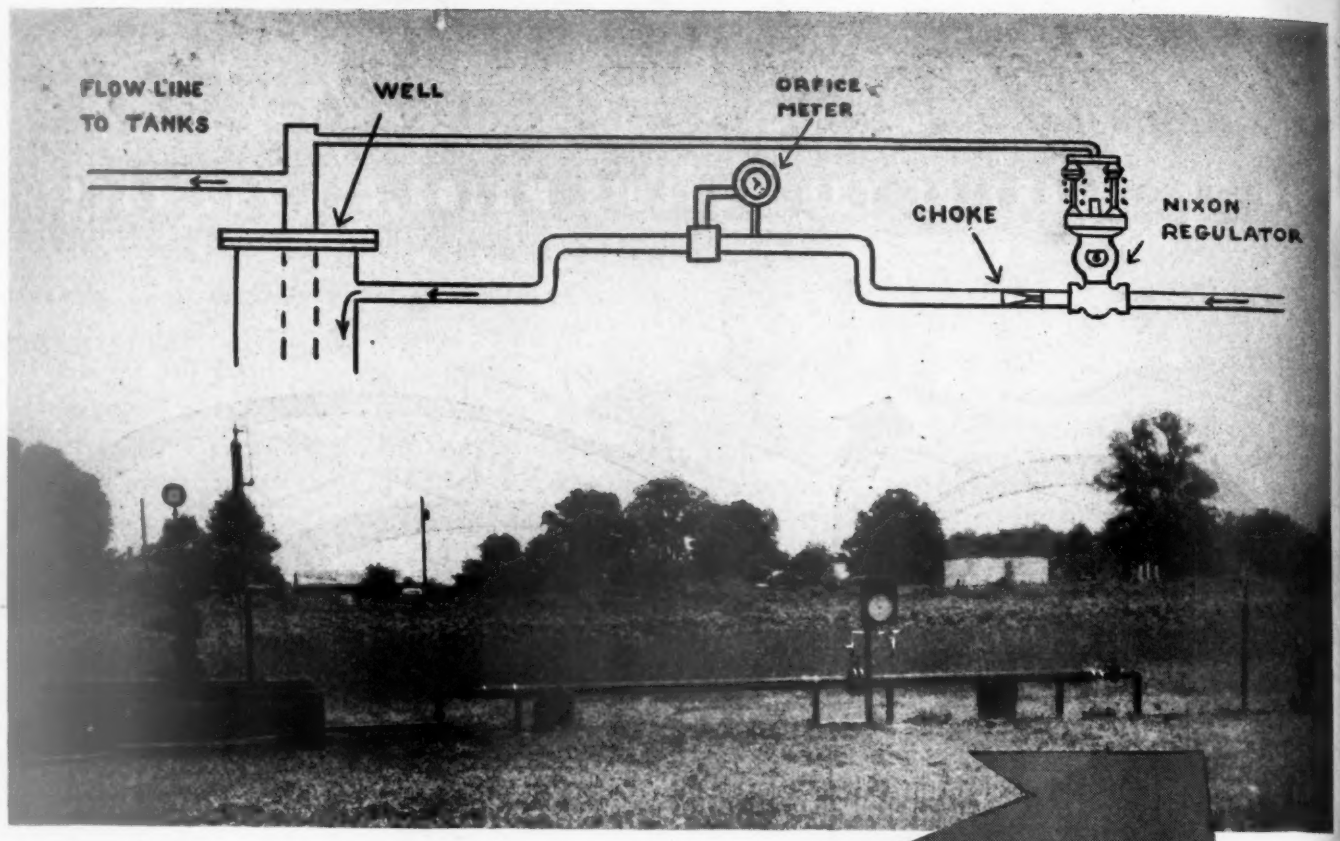
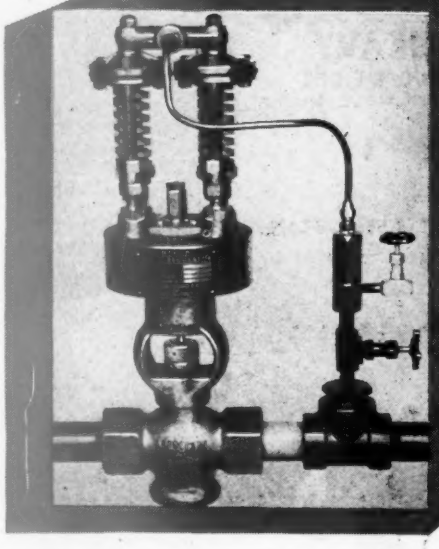
MECO

The Petroleum Engineer, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Irwin-Keasler Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25¢ a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the Act of March 3, 1879.



When Producing with Jet Collars ...Proportion Your Input GAS with A NIXON REGULATOR



The figures shown below furnish a good comparison of how the Nixon Regulator pays dividends by saving gas. They were taken "before and after" on the well pictured above.

WELL EQUIPPED WITH JET COLLARS ...STRAIGHT LIFT

Date	MCF	Net	Net/Ratio
March 29, 1945	151.8	33	4600/1
April 5, 1945	127.0	27	4650/1
May 13, 1945	152.1	33	4610/1
May 16, 1945	132.1	29	4625/1

WELL EQUIPPED WITH JET COLLARS AND NIXON REGULATOR

May 25, 1945	26.8	36	745/1
May 26, 1945	25.4	30	848/1
May 27, 1945	27.5	30	914/1

*A reduction in ratio of input gas of from 4621 cu. ft. to 836 cu. ft. per barrel of fluid lifted.

See Your Nearest Wilson Supply Store or Write.

WILSON SUPPLY COMPANY

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BRANCH STORES: TEXAS—Kilgore, Beaumont, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi. LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport. ARKANSAS—Magnolia. MISSISSIPPI—Natchez.

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FOR THE REFINER Who Must Install Modern Facilities To Meet Post-War Competition . . .

"Petroleum Refining Processes" — ninth of a series of annual brochures by Lummus — is now available. Containing data on a number of war-developed processes and combinations of processes, and supplemented by flow diagrams and photographs, "Petroleum Refining Processes" should be of interest to the refiner who is considering the adaptation of war-time facilities or the installation of new units to meet post-war competition.

Copies of "Petroleum Refining Processes" will be sent upon request.

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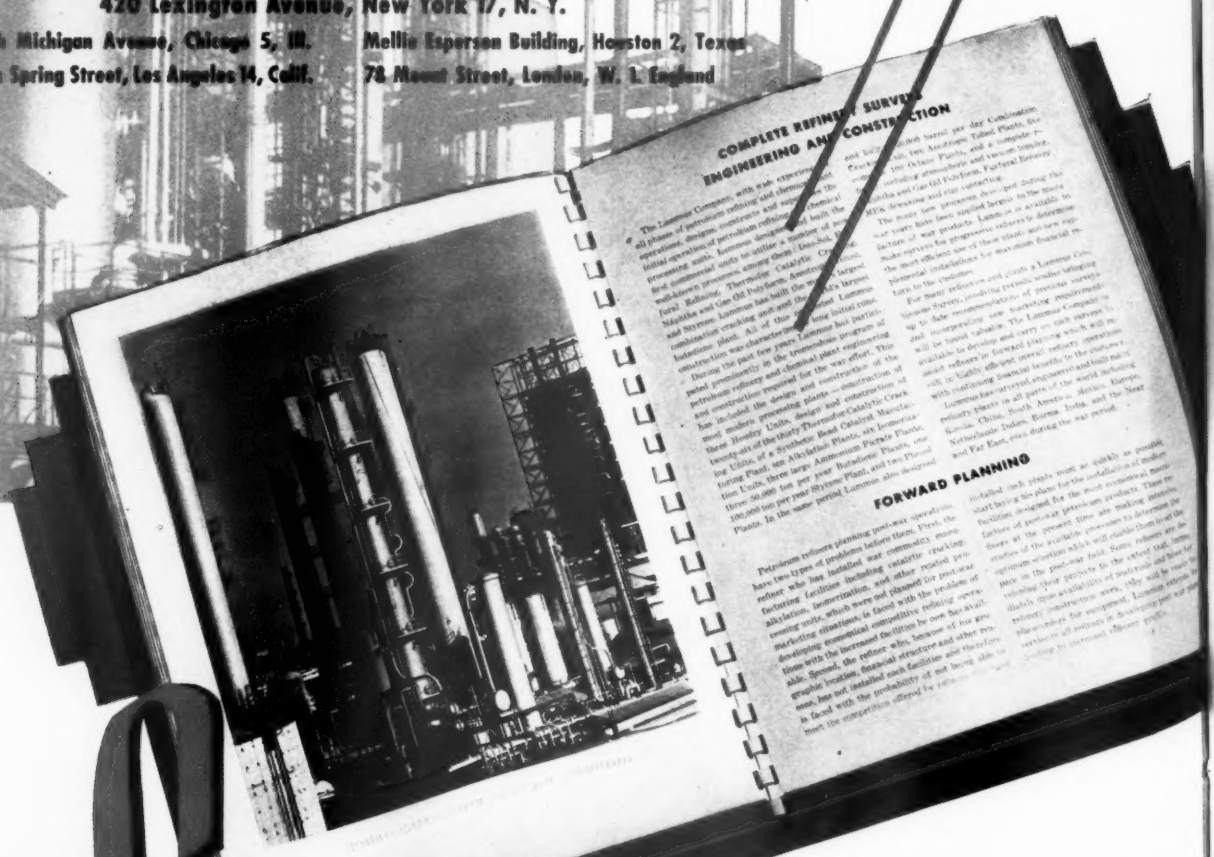

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PETROLEUM REFINING PLANTS

The "Pin-up" record shows the popularity of BALDWIN DIESELS

If you want to picture the importance of petroleum to the war effort . . . just imagine what would happen if the flow of oil would stop. Planes would be grounded, tanks immobolized, supplies halted, whole armies frozen in their tracks.

Even temporary interruptions are dangerous—which makes dependability a first requirement in diesel units for pipeline pumping service. Baldwin Diesels are engineered for such dependability, and you'll find them at work in many of the most important posts.

The map above gives some further evidence of Baldwin Diesel reliability. Every pin represents a Baldwin installation . . . and popularity like this has to be *earned.*

Next time you buy diesels, buy Baldwin. You'll find in them every proven new development that contributes to efficiency and economy, plus the fine engineering that the name "Baldwin" always guarantees.

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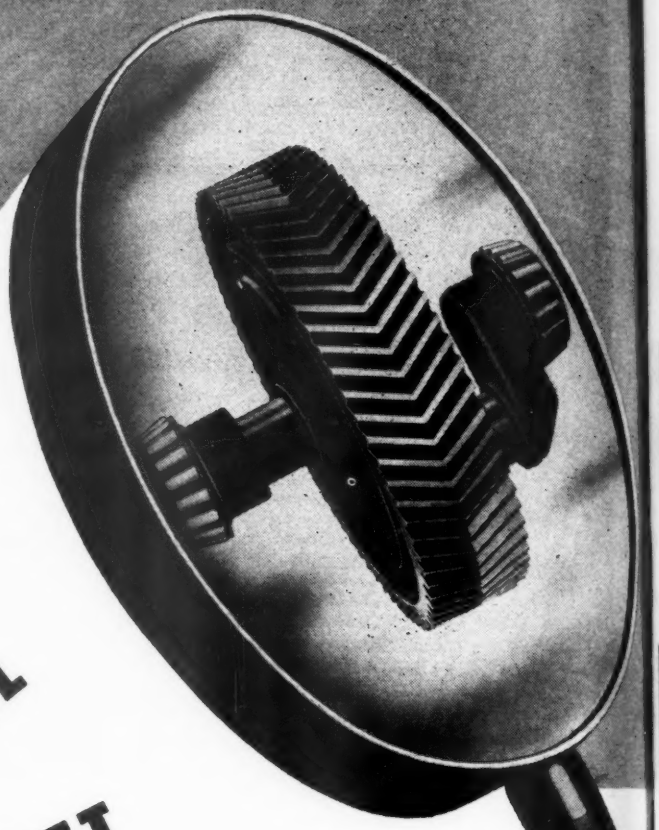
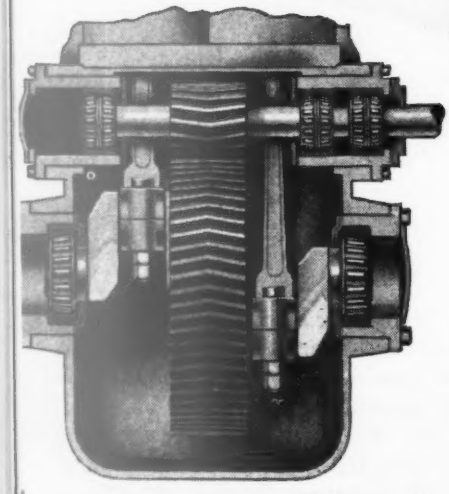


EXTRA-LARGE ALLOY STEEL CRANKSHAFT

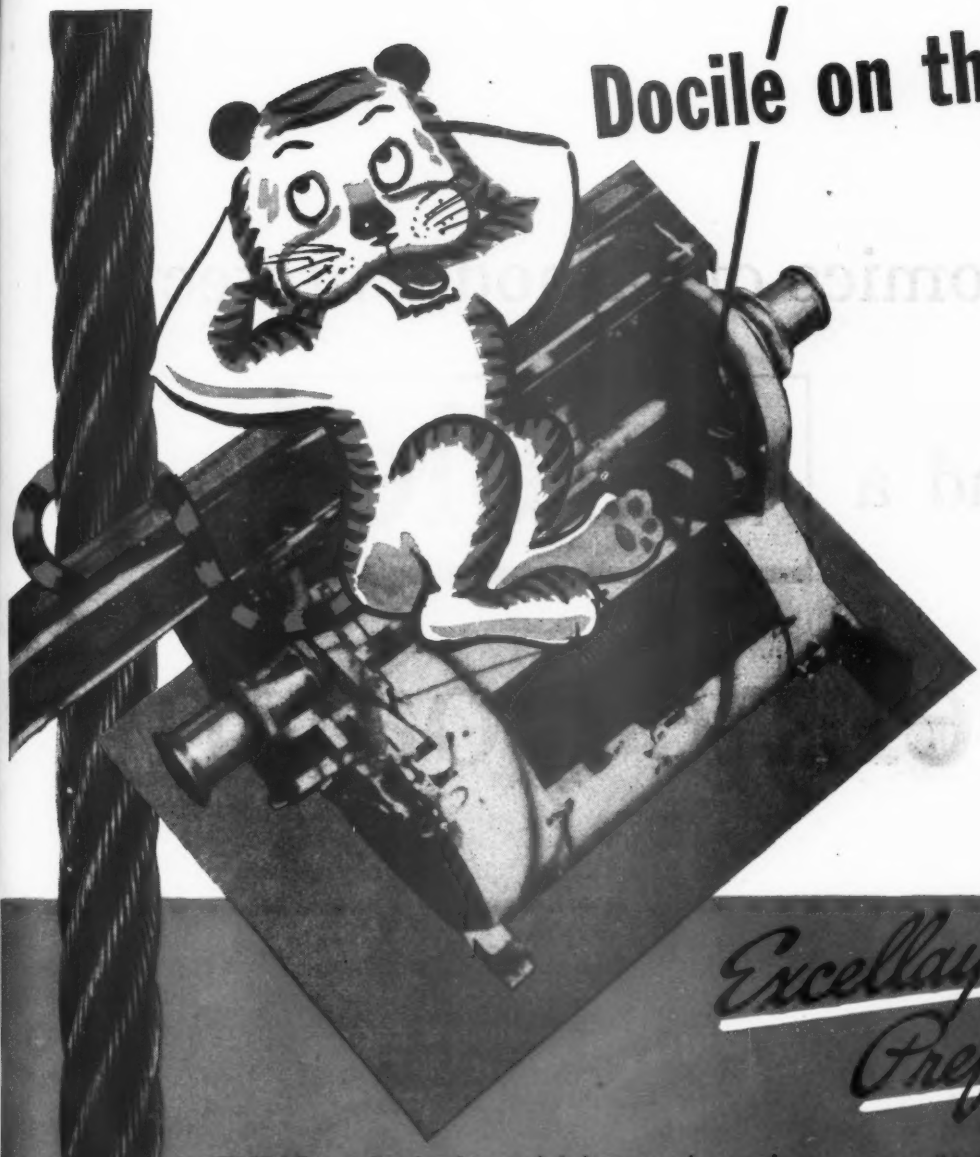


"Extra-large" is a word that appears frequently in Gaso specifications. It symbolizes a fundamental policy: Eliminate unnecessary parts but endow each part with an extra measure of strength and staying power. By proving a reserve of durability, Gaso design assures a bonus of pumping service which, in turn, represents extra dividends on the investment. ... Gaso Pump & Burner Mfg. Co., 902 East First Street, Tulsa, Okla. Export Office: 149 Broadway, New York. Shreveport: W. L. Somner Co., 419 Lake St. Los Angeles: Production Equipment Co., 651-653 E. Gage Ave.

GASO PUMPS

for every oil industry need

Docile on the Drum!



Excellay Preformed

JUDGE your line by the way it behaves on the drum. A cantankerous line can slow up your entire drilling operation.

For trouble-free performance on the drum, rig with U·S·S American TIGER BRAND Excellay Preformed Rotary Lines. These flexible lines do not spool away from—nor climb over—the next wrap.

They resist flattening out under heavy loads. This means less abuse to your rope as it winds on and off the drum.

Their toughness offers a greater safeguard to the crew responsible for the safe operation of the drilling equipment.

Other money-saving advantages of TIGER BRAND Excellay Preformed over non-preformed lines are: Greater strength and resistance to fatigue. Ability to stand up under severe bending as they run over the sheaves. Greater safety of handling—crown wires lie flat and in place even when broken.

See or call your distributor. More TIGER BRAND is being made available for civilian use.

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UNITED STATES STEEL

U·S·S AMERICAN
TIGER BRAND *Wire Rope*

The economics of cathodic protection

demand a stable pipeline coating

When considering the installation of Cathodic Protection for pipelines, it is important to select a pipe protection whose underground electrical insulating properties are not affected by varying moisture content of the soil during changes in season, weather or by time itself. Obviously, the correct amount of electrical current cannot be varied continually to compensate for the fluctuations in current required.

Barrett *Coal-tar* Enamels possess this all-important *stability* of high dielectric strength. Because of their resistance to moisture absorption, they provide a constant, uniform and long-lasting stable insulation.

Coal-tar Enamels, applied by the modern mechanical methods now in use, and electrically inspected, assure the proper continuity of a stable insulation—and require less current and smaller capacity equipment to make Cathodic Protection economical.

The effectiveness of Barrett Coal-tar Enamels in preventing corrosion in conjunction with Cathodic Protection has been established through years of service in all types of soil and climatic conditions. A dependable guide to engineers when designing corrosion-proof pipelines.

FIELD SERVICE: The Barrett Pipeline Service Department and staff of Field Service men are equipped to provide both technical and on-the-job assistance in the use of Barrett Enamel.

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Machined from the highest quality steels, each component part is checked and rechecked continually during manufacture and throughout service life.

This control is one of the important reasons why you can *call Lane-Wells and get the job done right!*

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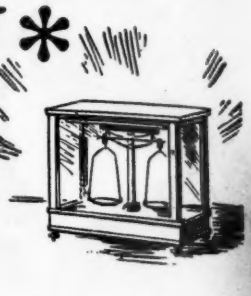

Who tests the test gauge?... is a question like "who wakes up the bugler?" Here is the way it is done on the most modern dead-weight tester. Test gauges like the one being checked are used in turn to check the indications of production gauges as illustrated below. We constantly re-check these test gauges on which the accuracy of production gauges depend.

. . . . Marsh Gauges have it and keep it

THE phrase "individually factory tested" can mean much . . . or little. All instruments are necessarily given some kind of final test, but unless this test is thorough and exhaustive some inherent inaccuracy may soon develop in service.

Every Marsh Pressure Gauge is put through tests that are bound to uncover the most remote source of trouble. There are many "go and no go" tests on individual parts in the manufacturing process, and the final test is made by experienced operators using the most accurate testing equipment.

Two phases of final testing are illustrated—the verification of test gauges, and the use of these test instruments in putting production gauges through their paces.

Yes, every Marsh instrument must prove accurate before it reaches you, and when it goes into service you will find that Marsh construction will *keep* it accurate even under the toughest conditions.

JAS. P. MARSH CORPORATION
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They must be right. The gauge under test must be made to agree with the extremely accurate test gauge—not just at one or two places on the scale, but all the way through.

GOOD NEWS FOR THE PETROLEUM INDUSTRY

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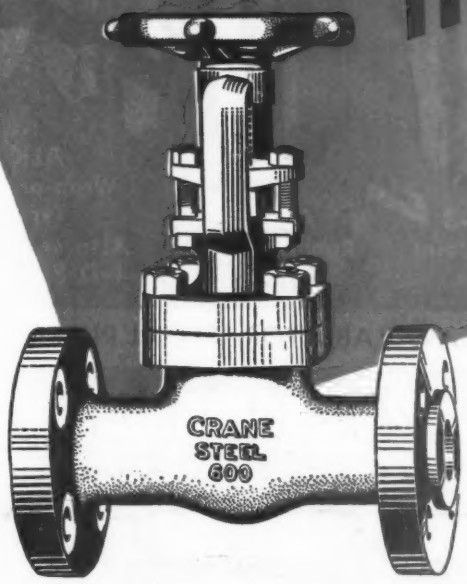
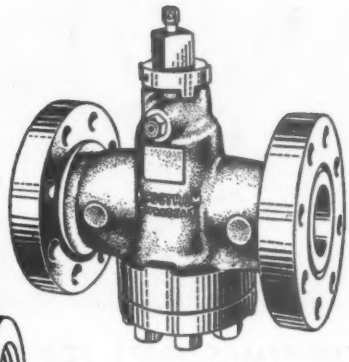
MARSH GAUGES

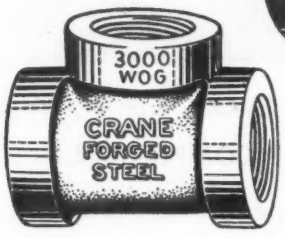
DIAL THERMOMETERS
HEATING SPECIALTIES

*One of a series of advertisements high-lighting the factors that make Marsh instruments "THE STANDARD OF ACCURACY"

For Service... Protection... THE Right VALVES AND FITTINGS







In a complex catalytic or thermal cracking unit, the gate, globe and plug valves and fittings are often guardians of an investment worth millions of dollars.

The valves and fittings handled by Bethlehem Supply can be relied upon for maximum plant protection, as well as for efficient service. In process areas where fire hazards are present, Bethlehem engineers recommend cast steel or forged steel valves with alloy seats and discs; and in the line, forged steel welding fittings.

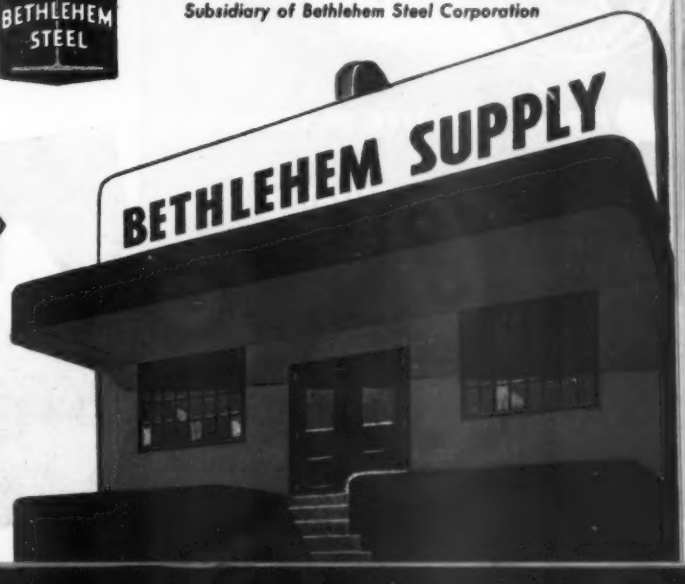
Correct valving is one of the cheapest forms of plant insurance. At Bethlehem Supply there are men who are trained in this work. It's part of their job. When you're planning, you can consult them with every confidence. They know the refinery industry, and they know valves.

When it's fittings you want, the same type of service is available. For quick delivery, inspect the stock at your nearest Bethlehem Supply Store. You'll find forged steel, cast steel, cast iron, malleable iron, and welding fittings in all the usual sizes up to 12-in. pipe diameter.

BETHLEHEM STEEL

BETHLEHEM SUPPLY COMPANY
Subsidiary of Bethlehem Steel Corporation

GHQ FOR REFINERY SUPPLIES



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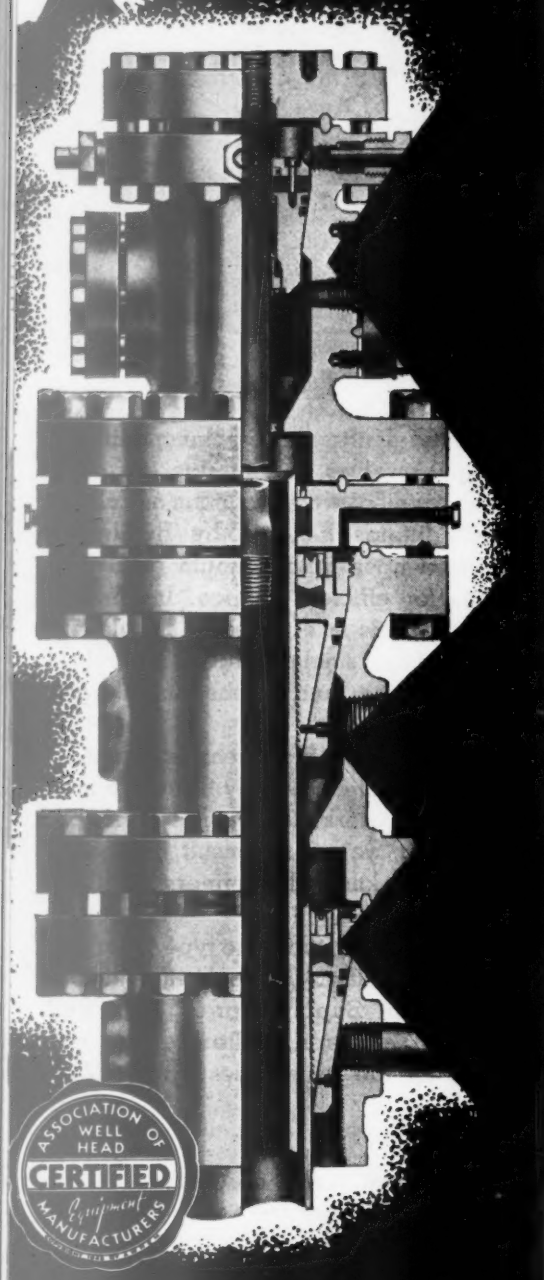
New



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OTHER HANGERS ARE AVAILABLE FOR SPECIAL PURPOSES

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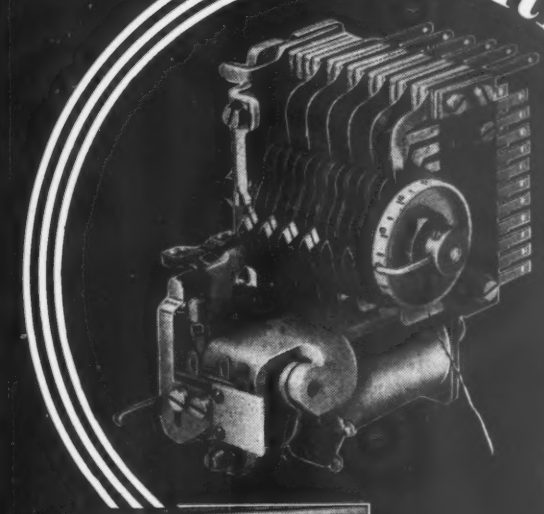

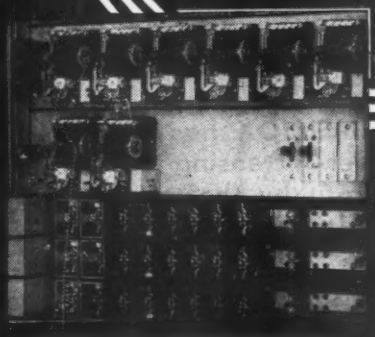

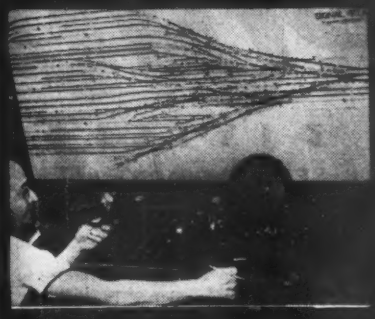

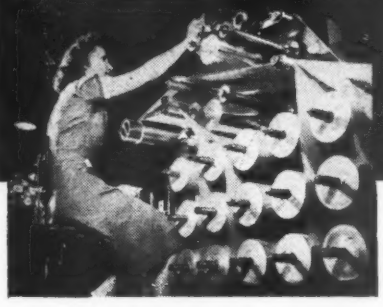

- in manufacturing operations
- in tests and measurements
- in signaling and timing
- in communications

Federal's FTR-800 Series *High-Speed* Automatic Selectors are available in 3 level-22 point and 4 and 6 level-11 point capacities.

Write for full information on this efficient Federal High-Speed Automatic Selector. Discover all the advantages it offers to you.

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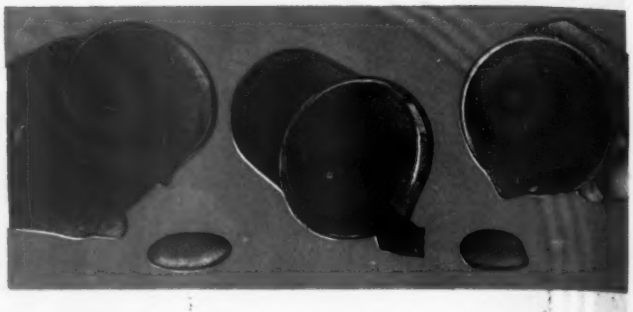
Cement-cut mud made usable again with **SMENTOX**

SMENTOX, a material for overcoming the effect of cement-contamination in drilling mud, eliminates the necessity of discarding all the contaminated mud in the system immediately after drilling out a cement plug. In eliminating the need for a complete mud change, SMENTOX saves many times its cost.

SMENTOX not only counteracts the effects of cement-cutting, but frequently as a result of the treatment the mud displays better performance characteristics than it did originally. For example, the gel-forming colloidal material in SMENTOX improves the wall-building properties of the mud.



Showing the effectiveness of SMENTOX. Beaker on left contains thin, uncontaminated drilling mud. Beaker in center contains same mud contaminated with cement (note how it maintains a highly viscous mass). Beaker at right contains the same mud as center beaker treated with SMENTOX (mud is fluid once more).

The success of SMENTOX has been proved by its ever-increasing use by operators who profit by the money and time-saving results of the treatment.

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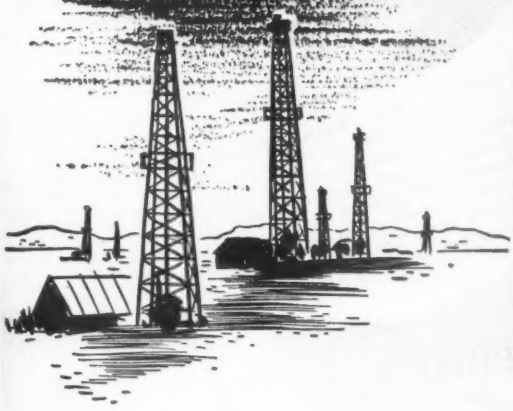
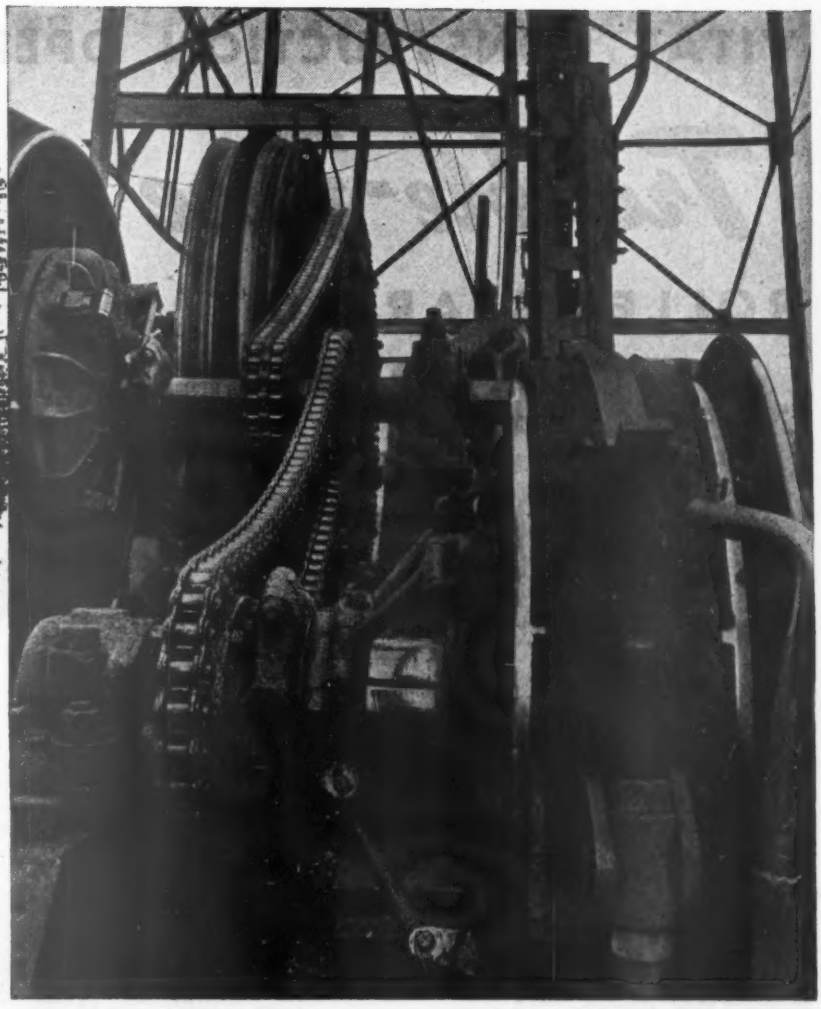
• **Patent Licenses** unrestricted as to sources of supply of materials, but on royalty bases, will be granted to oil companies and others desiring to practice the subject matter of any and/or all of United States Patents Numbers 1,807,082; 1,991,637; 2,041,086; 2,044,738; 2,064,936; 2,094,316; 2,119,829; 2,214,366; 2,294,877; 2,304,256 and further improvements thereof. Applications for Licenses should be made to the Los Angeles office.

LONG LIFE SEVERE SERVICE





—no other material can equal ALLOY STEELS

When the going is really rough—when strains are severe and concentrated—when shocks are heavy—when wear is rapid—where fatigue, heat, cold or corrosion take their toll—you will find the answer in alloy steels.

Alloy steels are processed to withstand severe service. They are made to be strong and tough. Their hardenability values are consistently uniform. And they resist the forces which cause failures in less sturdy materials.

The first cost of alloy steels may be higher than that of less efficient materials—but, with few exceptions, the final cost is lower. That is because alloy steels last longer and give the highest performance per dollar invested.

As the world leader in the production of alloy steels, Republic is ready to tell you how to use these steels to increase life and performance of chains, shafts, gears, bearings and other drawworks parts—of drill bits, pumps, kellys, slips, blocks, swivels and similar operating equipment. Write today.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC STEEL — PRODUCTION FOR VICTORY

ALLOY STEELS

Also Casing—Tubing—Line Pipe—U

VITAL CONSTRUCTION OPERATIONS DEMAND

Trouble-Free

ROLLER BEARING OPERATION

Trackson Pipe Laying cranes, working on large diameter pipe line. While one machine squats on pipe, it and companion machine lift free end to bend it, to conform to profile of trench. Arrow indicates location of Link-Belt Roller Bearings, in winch mechanism.

Rapid extension of pipelines throughout the country is undoubtedly an important factor in the speedy response of America's industry to the challenge of war production.

American inventiveness, expressed in such specialized equipment as the pipe line machinery developed by Trackson Company of Milwaukee, is making new construction records possible. Carrying tremendous loads over all types of ground, on steep slopes as well as on the level, every part of these machines must be capable of withstanding every conceivable strain. For the main power shaft for the cable drums, Trackson Company selected Link-Belt Roller Bearings because they assure full load capacity and free rolling action even in the presence of misalignment and shaft deflection. They are available in ball or roller types, unmounted or mounted, in pillow blocks, hangers, flanges or take-up mountings. Send for data book No. 1775-A for full engineering and application data.

LINK-BELT COMPANY

Indianapolis 6, Dallas 1, Houston 2, Kansas City 6, Mo., Los Angeles 33, New York 7, Toronto 8. Offices in Principal Cities. 2623-B

LINK-BELT

BALL AND ROLLER BEARINGS

GARDNER-DENVER *Power* SLUSH PUMPS

▲ Uniform design of all sizes throughout the entire line—*a Gardner-Denver exclusive.*

▲ Rigid Main Shaft assures perfect alignment—*making for quiet operation and low maintenance.*

▲ Large Bearing areas on eccentrics reduce wear to a minimum—*resulting in long, trouble-free operation.*

▲ Oil-stop, Mud-stop heads and piston rod baffles—*completely and positively prevent entrance of mud and water into power end lubrication system.*

▲ Divided fluid end construction—*cast of GarDurloy Alloy mixture developed especially for mud pump fluid cylinders.*

THE CONTINENTAL SUPPLY COMPANY
General Offices: DALLAS, TEXAS
EXPORT DIVISION
30 Rockefeller Plaza New York City, N. Y.
Representatives
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CONTINENTAL

Serving the Oil and Gas Industries

There is a Swab that can take it...and dish it out, too!

The Type K Swab with exclusive Guiberson flexible basket type fluid cups can really take it on the tough jobs. Flexible cup construction prevents wear while running in the hole and allows cup to take up its own wear while swabbing. And when it comes to dishing it out, the Guiberson swab falls faster than the swabbing line will unreel from the drum and gives greater fluid passage through the mandrel than any other make of swab. Pulls a full load at every stroke. Cups are easy and quick to change. Available in all standard sizes, the cups will fit slightly varying diameters of tubing and casing.

The Guiberson flexible basket type swab takes up its own wear, assuring a complete seal even after cup begins to wear. Swab cups are Guiberson's own special rubber compound that resists abrasion and gives maximum tensile strength.

TYPE "K" SWAB

Principle of conventional swab.

Principle of Guiberson swab.

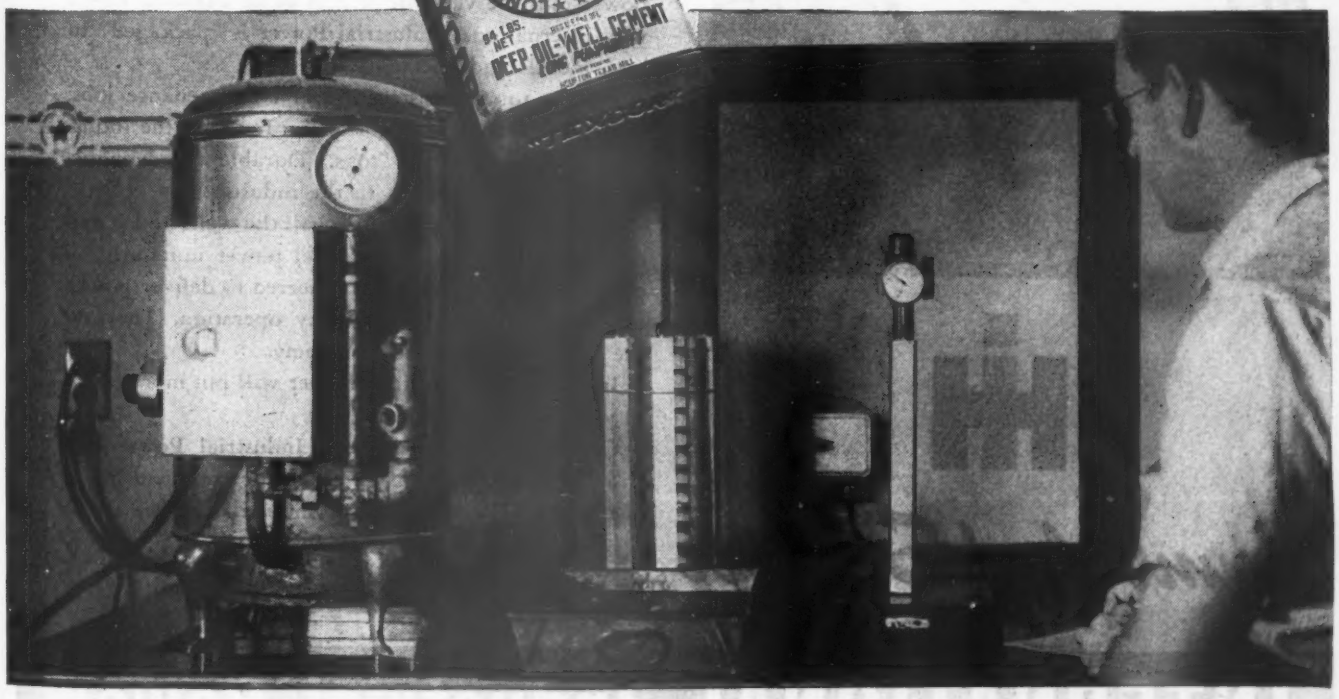
Guiberson U.S.A. THE GUIBERSON CORP.
ESTABLISHED 1919 DALLAS, TEXAS

EXPORT REPRESENTATIVE: I. Frank Brown, 30 Rockefeller Plaza, New York City, New York
CALIFORNIA DISTRIBUTOR: W. R Guiberson Co., 717 East Gage Avenue, Los Angeles, California

LONE STAR CEMENTS ARE PRE-TESTED

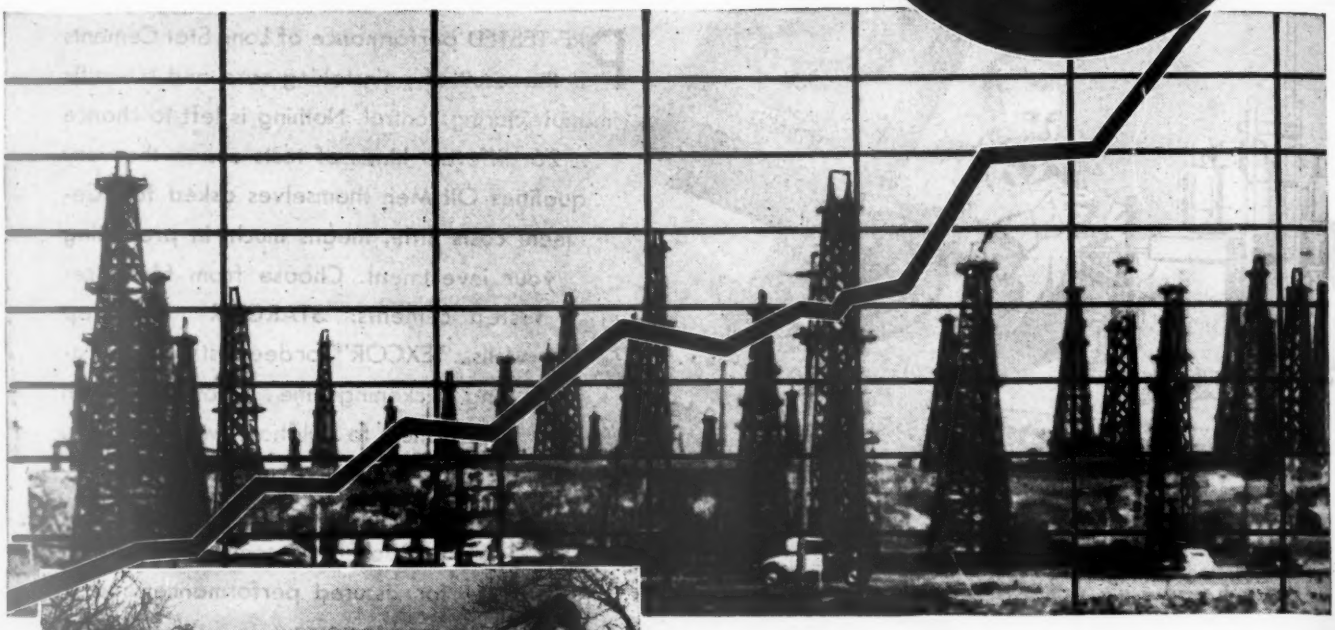
26 Different Ways

PRE-TESTED performance of Lone Star Cements is the result of painstaking care and scientific manufacturing control. Nothing is left to chance . . . 26 different kinds of tests assure the very qualities Oil Men themselves asked for. Cement costs little, means much, in protecting your investment. Choose from four pre-tested cements: 'STARCOR'* for deep wells...'TEXCOR'* for deepest wells, extra-long thickening time . . . both with high resistance to sulphate-water action. 'Incor'* for wells of moderate depth... Lone Star Cement for all-around service. Backed by continuing research for assured performance, today and tomorrow. *Reg. U.S. Pat. Off.



LONE STAR CEMENT CORPORATION • DALLAS • HOUSTON

POWER Charts Production



Like an unseen hand, power charts your production. Efficient power means high-level production. But power must be versatile if it is to be efficient. That's why International Industrial Power is "packaged" in both mobile and stationary units.

For the tough construction and maintenance jobs, the four powerful Diesel TracTracTors and the industrial wheel tractors are "tops." Durable and dynamic, their reputation is high in the industry.

Where power is needed to drill the wells and pump out the oil, International Diesel power units are the popular choice. They are engineered to deliver power under gruelling night and day operation. They do the job with the strictest economy.

International Industrial Power will put more peaks in your production chart.

Contact your International Industrial Power distributor today. Let him give you the complete information on his wide range of industrial power units.

Symbol of Service

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue Chicago 1, Illinois

INTERNATIONAL Industrial Power

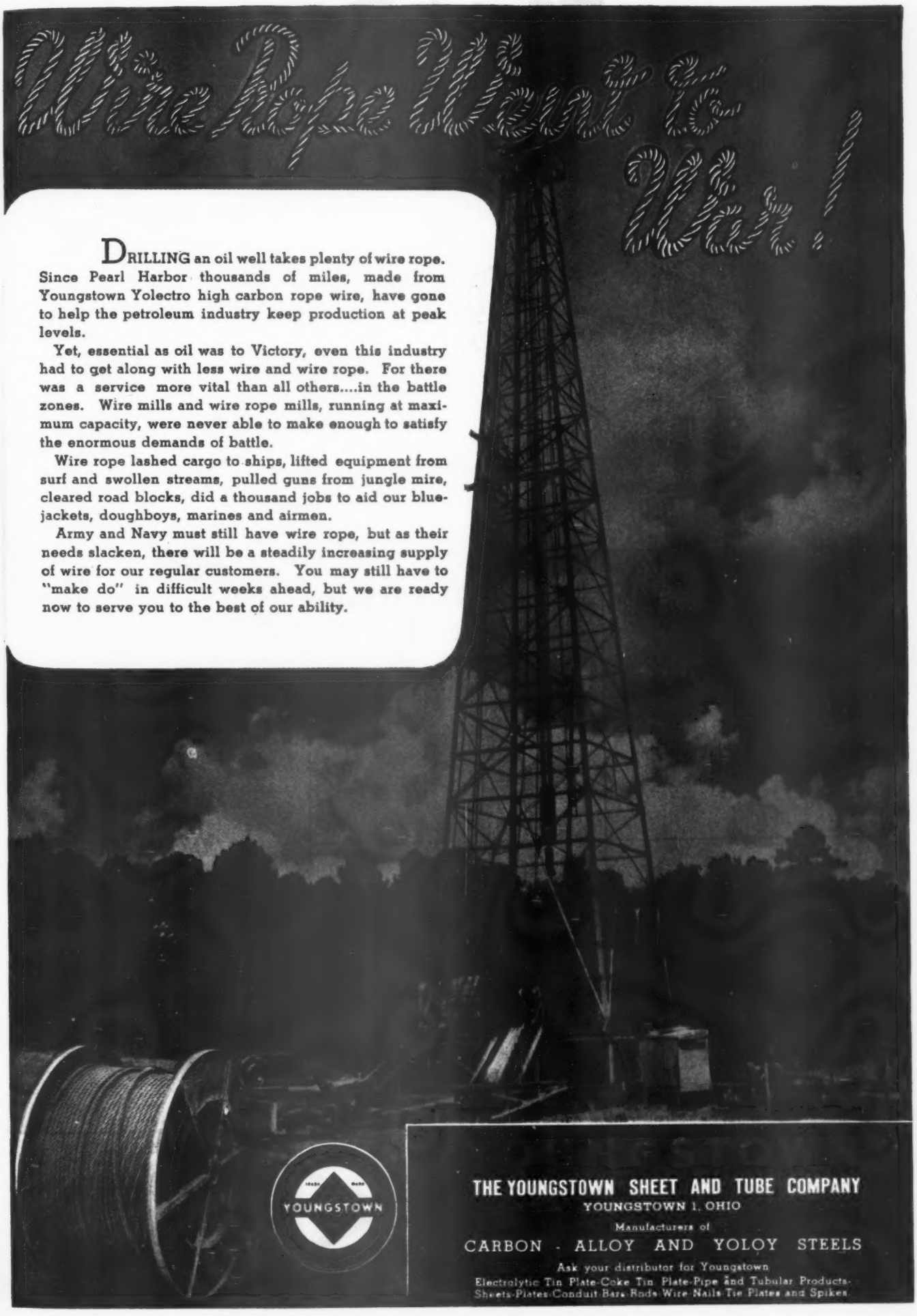
Wire Rope Hauls Ass!

DRILLING an oil well takes plenty of wire rope. Since Pearl Harbor thousands of miles, made from Youngstown Yolectro high carbon rope wire, have gone to help the petroleum industry keep production at peak levels.

Yet, essential as oil was to Victory, even this industry had to get along with less wire and wire rope. For there was a service more vital than all others....in the battle zones. Wire mills and wire rope mills, running at maximum capacity, were never able to make enough to satisfy the enormous demands of battle.

Wire rope lashed cargo to ships, lifted equipment from surf and swollen streams, pulled guns from jungle mire, cleared road blocks, did a thousand jobs to aid our bluejackets, doughboys, marines and airmen.

Army and Navy must still have wire rope, but as their needs slacken, there will be a steadily increasing supply of wire for our regular customers. You may still have to "make do" in difficult weeks ahead, but we are ready now to serve you to the best of our ability.



YOUNGSTOWN

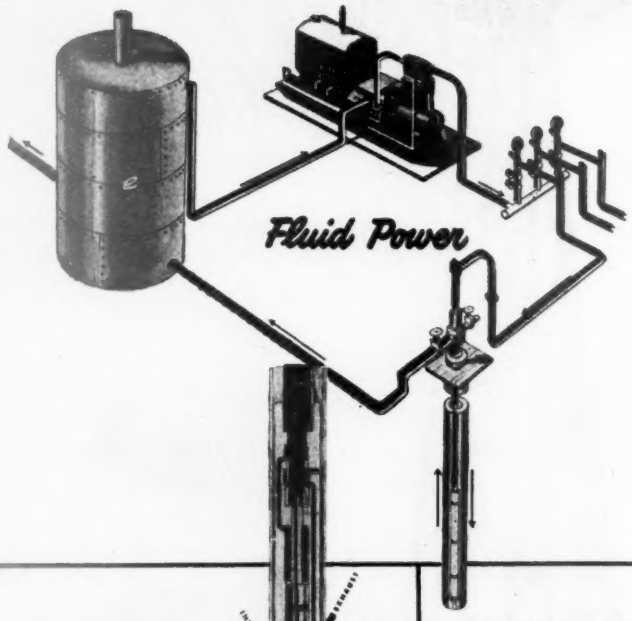
THE YOUNGSTOWN SHEET AND TUBE COMPANY
YOUNGSTOWN 1, OHIO

Manufacturers of
CARBON - ALLOY AND YOLOY STEELS

Ask your distributor for Youngstown
Electrolytic Tin Plate-Coke Tin Plate-Pipe and Tubular Products-Sheets-Plates-Conduit Bars-Rods-Wire-Nails-Tie Plates and Spikes

LET *Fluid Power*

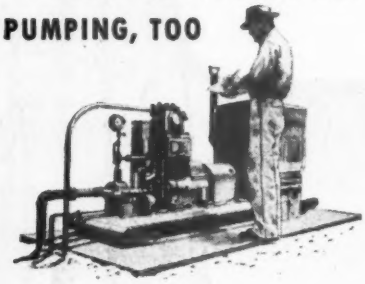
GIVE YOU THESE PUMPING ADVANTAGES



BOTH STROKES COUNT WHEN YOU PUMP WITH KOBE

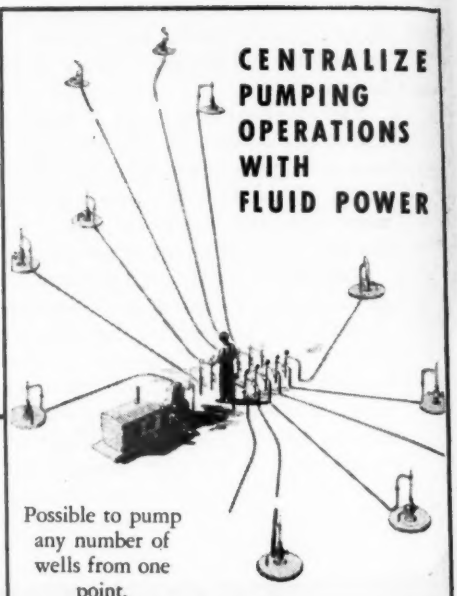
Delivers oil at every stroke—up or down.

RIGHT FOR SINGLE UNIT PUMPING, TOO



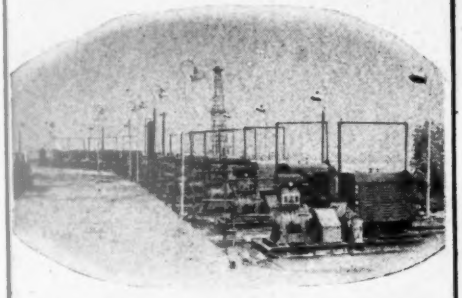
Efficient, Flexible, Portable

CENTRALIZE PUMPING OPERATIONS WITH FLUID POWER



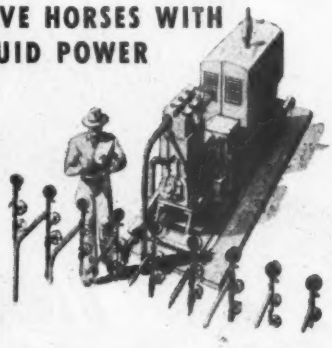
Possible to pump any number of wells from one point.

KOBE PUMPS 'EM DEEP



Now pumping 1,000 B/D from 8400 feet.

SAVE HORSES WITH FLUID POWER



High efficiency saves horsepower.

LET FLUID POWER DO THE TRACK WORK

Location of production control all at one place—saves pumper's time and energy.

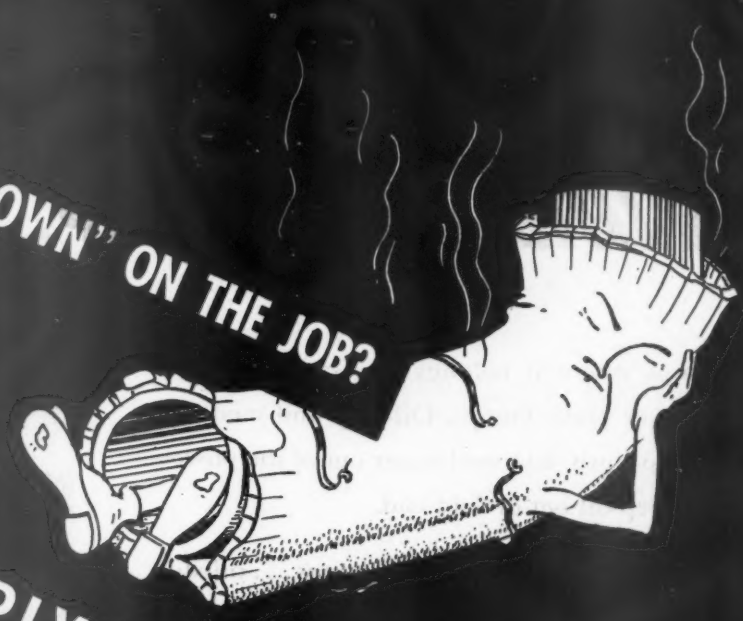
KOBE, Inc. — *General Offices & Plant: 3040 East Slauson Ave., Huntington Park, Calif. Mid-Continent Division Offices and Shops: 230 S. E. 29th St., Oklahoma City, Okla. California Division Offices: 217 Wilson Bldg., Huntington Park, California. Export Agent: Petroleum Machinery Corporation, 30 Rockefeller Plaza, New York, N. Y.*

KOBE

ONE OF THE [illegible] INDUSTRIES

PUMP THE MODERN WAY— USE KOBE

INSULATION "FALLING DOWN" ON THE JOB?



SIMPLY APPLY UNIBESTOS

it's simple to apply!

Here's an insulation that won't "fall down" on the job! Unibestos will not sag, gap, shatter or shakedown under the most severe vibration—always remains snug and firm against pipe, thus assuring maximum protection with a minimum of heat loss. Moreover, Unibestos efficiency is unaffected by moisture. Even when soaked, moisture can be steamed off without damaging Unibestos structural strength.

Unibestos is available in half-section form up to 30" pipe diameter, and in quarter-section form from 32" to 60"—in thicknesses from ¾" to 5". Single layer construction is available for service up to 1200°.

ARMY ARMY E NAVY

UNION ASBESTOS
MEANS PROGRESS IN INSULATION
AND RUBBER CO.

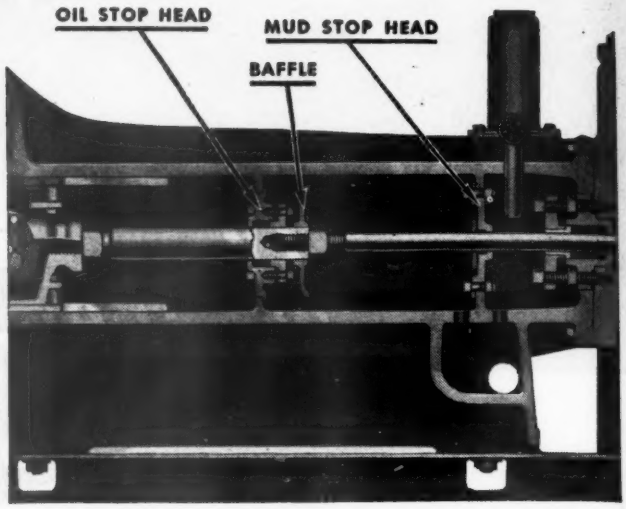
COPYRIGHT 1944
UNION ASBESTOS AND RUBBER CO.

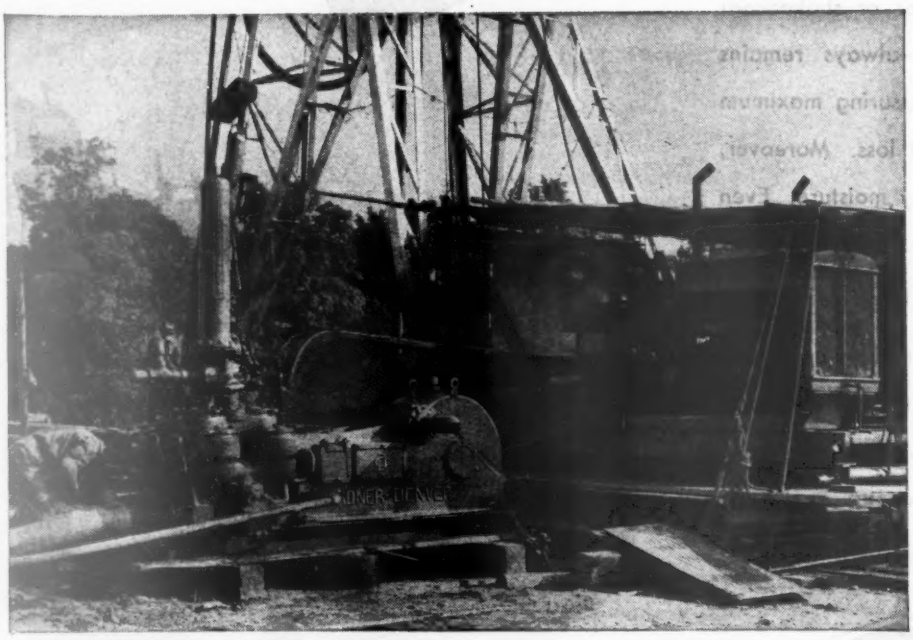
PLANTS: 1821 S. 54th Ave., CICERO, ILL. • PATERSON, N. J. • BLUE ISLAND, ILL.
OFFICES: CHICAGO • CICERO, ILL. • NEW YORK • SAN FRANCISCO • PATERSON, N. J.

MUD WON'T CLOG THE WORKS ON *THIS* SLUSH PUMP...

Mud stays where it belongs on Gardner-Denver "FX" Power Slush Pumps. Oil-stop and mud-stop heads keep slush, dust and water out of the power-end . . . keep oil out of fluid-end.

In the frame three protective features . . . oil-stop head, water deflector and mud-stop head . . . combine to prevent leakage into the crankcase. Water flushing pipes assist in keeping piston rods clear of any mud escaping from fluid-end stuffing boxes. Mud can't clog the works on these pumps.



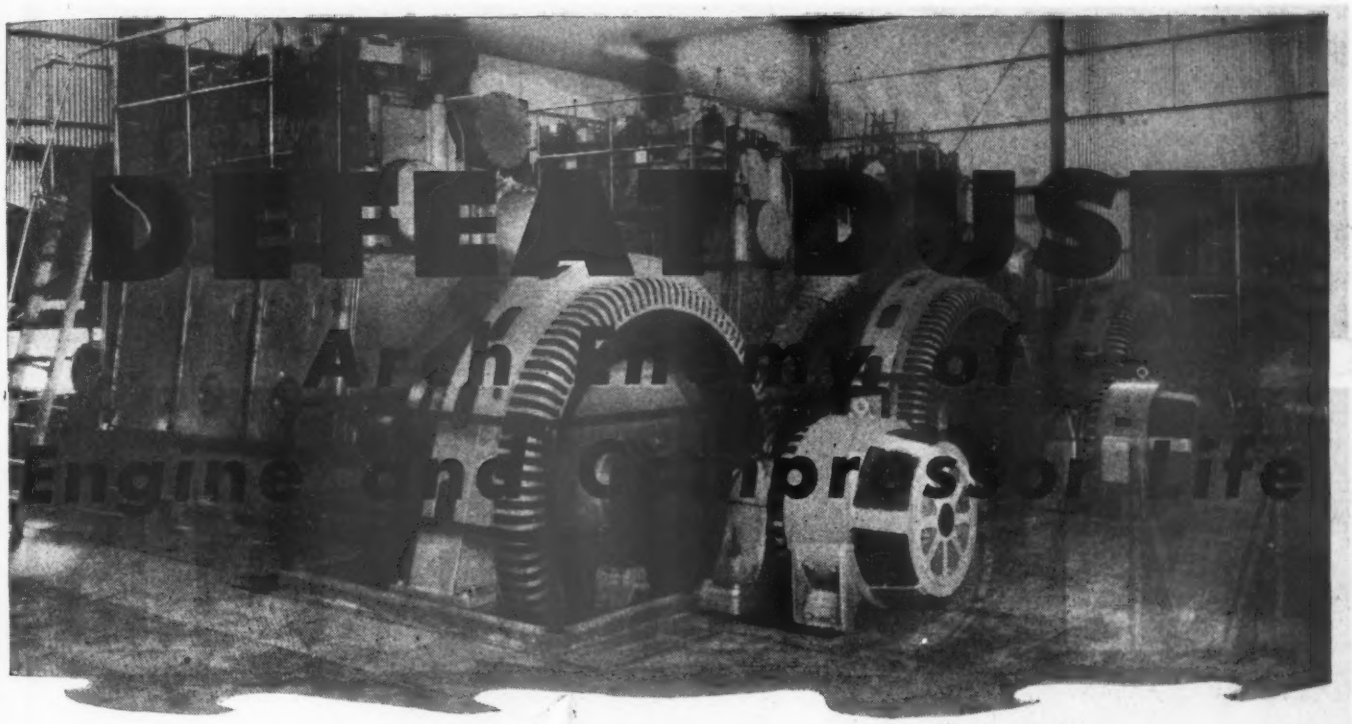


For complete information on Gardner-Denver "FX" Power Slush Pumps, write Gardner-Denver Company, Quincy, Illinois • Dallas • Houston • Tulsa • St. Louis • Los Angeles • San Francisco New York • Chicago • Pittsburgh • Denver. Continental Supply Co., Continental Bldg., Dallas, Texas. Republic Supply Company (of California), 2122 E. 7th Street, Los Angeles, California.

OTHER "FX" FEATURES

- Fluid cylinders, frames and other parts cast in GarDurloy for extra strength and resistance to wear.
- Divided fluid cylinder construction—no inner baffles to be cut through by mud.
- Rugged main frame cast in one piece for greater resistance to shock loads.
- Positive flood-type lubrication assures adequate lubrication of all working parts.
- "Slush-proof" hardened liners, rods and valves.

GARDNER-DENVER *Since 1859*

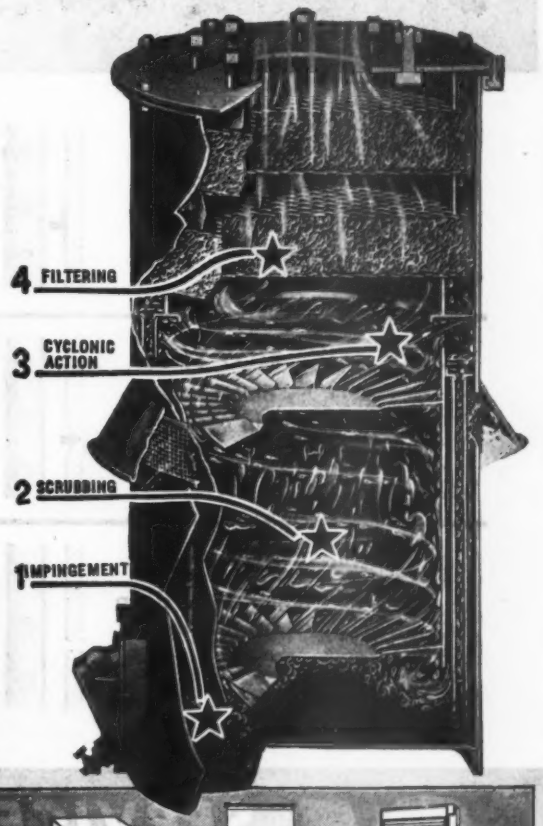


WHEN you protect power equipment with AAF air cleaners you prevent the unnecessary costly, time-consuming breakdowns which always result from excessive wear caused by abrasive dust and grit that attacks the vitals of your engines and compressors.

Throughout the nation, Cycoil cleaners are prolonging the useful life of valuable power equipment —permitting uninterrupted operation on stepped-up running time and accelerated production schedules.

The cost of Cycoil's "preventive maintenance" is insignificant compared to savings in wear, running time and man-hours. Send for facts on the Cycoil and other AAF engine and compressor filters for every air and gas cleaning requirement.

THE CYCOIL OIL BATH AIR CLEANER

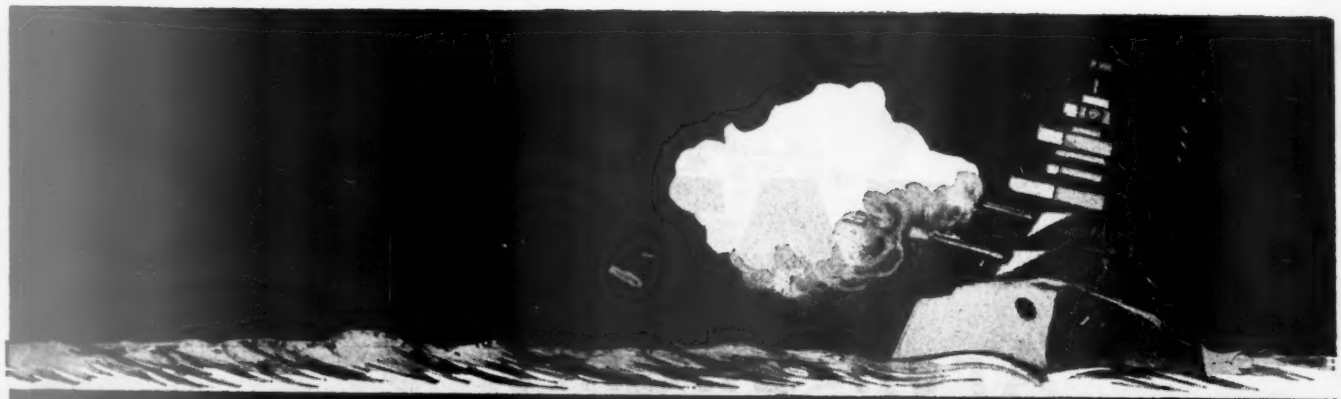


The fundamental advantage of the Cycoil Oil Bath cleaner is that the incoming air stream picks up an unusually large quantity of oil which is thoroughly mixed with the air (causing a scrubbing or precleaning action), and then thrown out by centrifugal action before the air stream enters the filter cell. This results in reducing the dust load on the filter cell and insuring continued self-cleaning action.

AMERICAN AIR FILTER CO. INC.
384 Central Avenue, Louisville, Kentucky
In Canada: Darling Bros., Ltd., Montreal, P. Q.

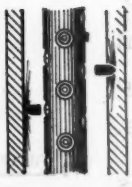
AAF

AMERICAN AIR FILTERS for ENGINES and COMPRESSORS

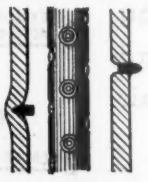


McCullough

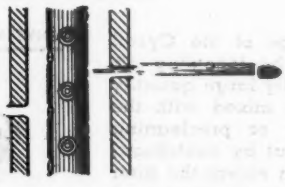
NOT THIS
Bullet does not penetrate



NOT THIS
Bullet sticks in casing



BUT *THIS*
Bullet drives deep into formation



The mission of the armor-piercing shells hurled by a battleship is **not** just to punch holes in the armor plate of an opposing ship, but to drive **through** that armor and shatter the installations beyond it. Just so, McCullough Armor-Piercing Bullets are designed to punch cleanly through the casing and drive deep beyond it to open up the formation — and they **do** it! Field tests have proved, time after time, that McCullough Gun Perforating gives Greater Penetration. That's what you want, isn't it?

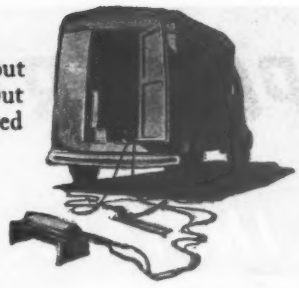
21 SERVICE LOCATIONS

McCULLOUGH TOOL COMPANY . . . 5820 South Alameda Street, Los Angeles 11, California
Export Office: 30 Rockefeller Plaza, New York 20, N.Y.

HOUSTON, TEXAS
WICHITA FALLS, TEXAS
VICTORIA, TEXAS
CORPUS CHRISTI, TEXAS
ODESSA, TEXAS
TYLER, TEXAS
McALLEN, TEXAS
ALICE, TEXAS
NEW IBERIA, LA.
SHREVEPORT, LA.
HOUMA, LA.
LAKE CHARLES, LA.
OKLAHOMA CITY, OKLA.
GUYMON, OKLA.
LAUREL, MISSISSIPPI
CASPER, WYO.
LOS ANGELES, CALIF.
VENTURA, CALIF.
BAKERSFIELD, CALIF.
AVENAL, CALIF.
SACRAMENTO, CALIF.

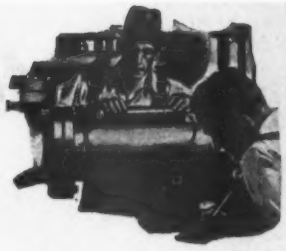
PENETRON I —

Measured thickness without drilling and calipering but weighed 400 lbs — required a trailer to carry it.

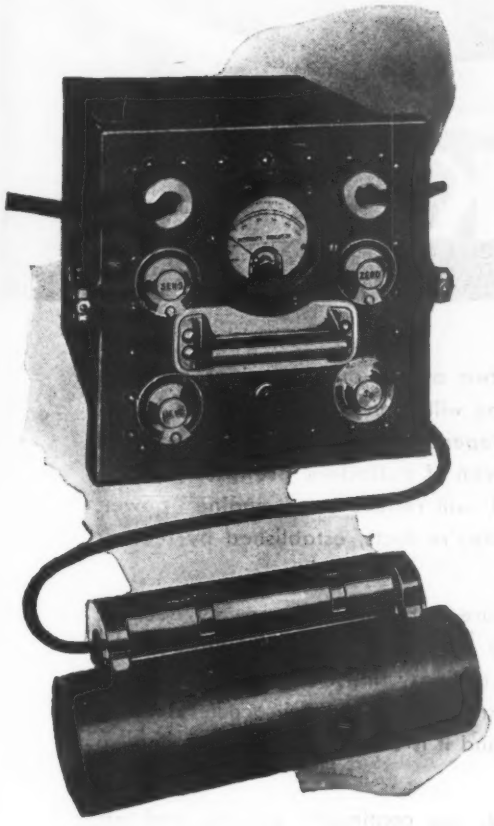


PENETRON II —

Achieved portability without loss of accuracy. Weight, only 40 lbs.



Research in Action!



PENETRON III —

Thanks to continuing research today's Penetron is *easily* portable yet even more sensitive. It weighs only 25 lbs.

How continuing Texaco Research developed a radically new idea and then made it better and better

THE PROBLEM: The drilling and calipering of oil industry equipment to check corrosion is costly, time consuming and often unsatisfactory. Texaco Research sought a better method that would quickly and accurately measure the thickness of a pipe or vessel *working from one side only.*

FIRST SOLUTION: After careful consideration exhaustive experiments with radium were undertaken. This resulted in the original Penetron, an efficient instrument but so heavy it had to be carried in a trailer.

SECOND SOLUTION: Further research reduced the weight from 400 to 40 lbs. The instrument was now portable and equally efficient but still heavy.

PRESENT SOLUTION: An instrument of even greater accuracy weighing only 25 lbs.

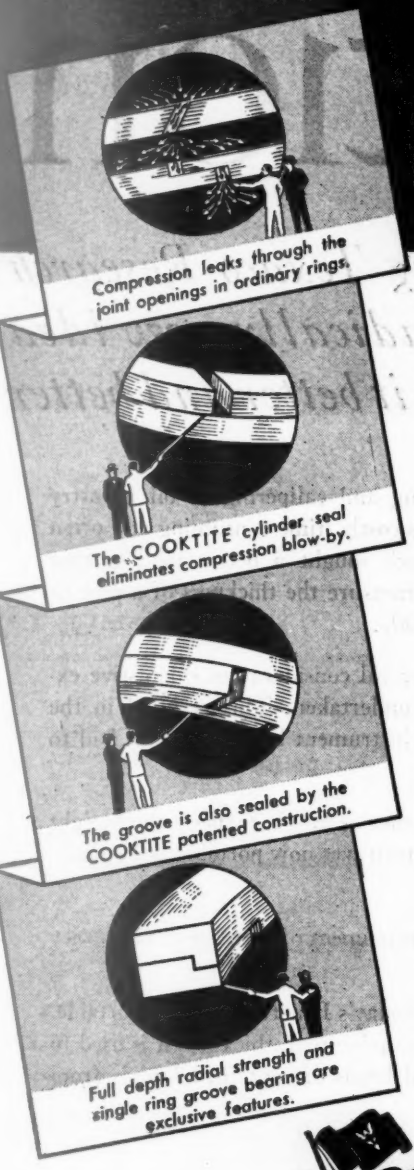
Thanks to Texaco Research today's Penetron is easily portable, easier to use. In addition to measuring wall thickness it is used to determine both the density and levels of contained liquids from outside the equipment.

TEXACO

TEXACO DEVELOPMENT CORPORATION

A Subsidiary of The Texas Company

... INSTALL COOKTITES


Compression leaks through the joint openings in ordinary rings.
The COOKTITE cylinder seal eliminates compression blow-by.
The groove is also sealed by the COOKTITE patented construction.
Full depth radial strength and single ring groove bearing are exclusive features.

YES, by simply replacing two of the ordinary rings on each piston with COOKTITES you will immediately get more horsepower—up to 25% more, depending on your engine's present cylinder wear condition. Even if cylinders are badly worn, COOKTITES, properly applied, will restore "new engine" power. These are not just theories. They're facts, established by records of thousands of installations.

And why will COOKTITES assure increased horsepower? Because they will completely stop the leak of compression through the unsealed gap opening of the ordinary rings. True, this "blow-by" through the ordinary rings is small at first—but it accelerates fast as rings and cylinders wear, and it is a big factor in speeding up the wear.

Thus, with ordinary rings only, you continually get less and less power from the fuel burned—which, of course, means a progressively greater waste of fuel. Put a couple of COOKTITES on each piston and you end all this, because there are no gap openings in COOKTITE construction through which pressure can escape. From the start, COOKTITES provide a 100% positive cylinder seal—and they maintain it as long as they last. Many other advantages also result when you install COOKTITES.

Of course, you want the full story. It's yours for the asking. Write for it—today.

Sealing Pressures Since 1888

C. LEE COOK MANUFACTURING CO.

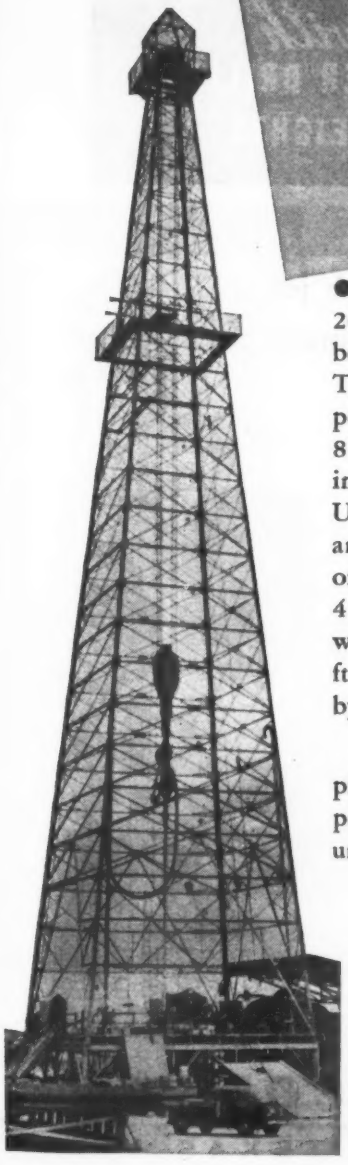
INCORPORATED

LOUISVILLE, KY.

BALTIMORE • BOSTON • CHICAGO • CLEVELAND • HOUSTON • LOS ANGELES • MOBILE • NEW ORLEANS • NEW YORK • SAN FRANCISCO • TULSA

Right (exhaust) side of Model 6-LROU Waukesha Gas or Gasoline Six Cylinder Oil Field Power Unit.

WAUKESHA-POWERED four-engine RIG *makes more hole...* FASTER and DEEPER



● The derrick is the world's tallest—202 ft. The rig is said by its makers to be the largest on the market—an Ideal Type 125 *Consolidated*. It's adequately powered with Model 6-LROU 6-cyl., 8½ x 8½ in. bore and stroke, 2894 cu. in. displ. Waukesha Oil Field Power Units—*four of 'em*—burning natural gas and developing an aggregate maximum of 1600 horsepower. The location—4 miles northeast of Monahans, Texas, where deep production, to about 11000 ft., was discovered about three years ago by one of the large oil companies.

Using the big derrick, with 5⅝ in. pipe and 135 ft. stands, this Waukesha-powered set-up with its four Waukesha units has *super-power*—fast, flexible, smooth, responsive—to carry on the drilling program.

Normally two Waukeshas operate one of the heavy duty NSCO Model C-350 pumps; the other pair drives the drawworks and rotary table. Three engines may be used for either job. Usually one engine is available for mixing mud. With these four Waukesha Engines, the rig has a high standby factor. Three engines can always run the entire rig at practically full efficiency. At any time one engine may be serviced without interrupting operations. *Get* Bulletin 840. Consult Waukesha engineers on your future engine needs.

WAUKESHA MOTOR COMPANY, WAUKESHA, WISCONSIN
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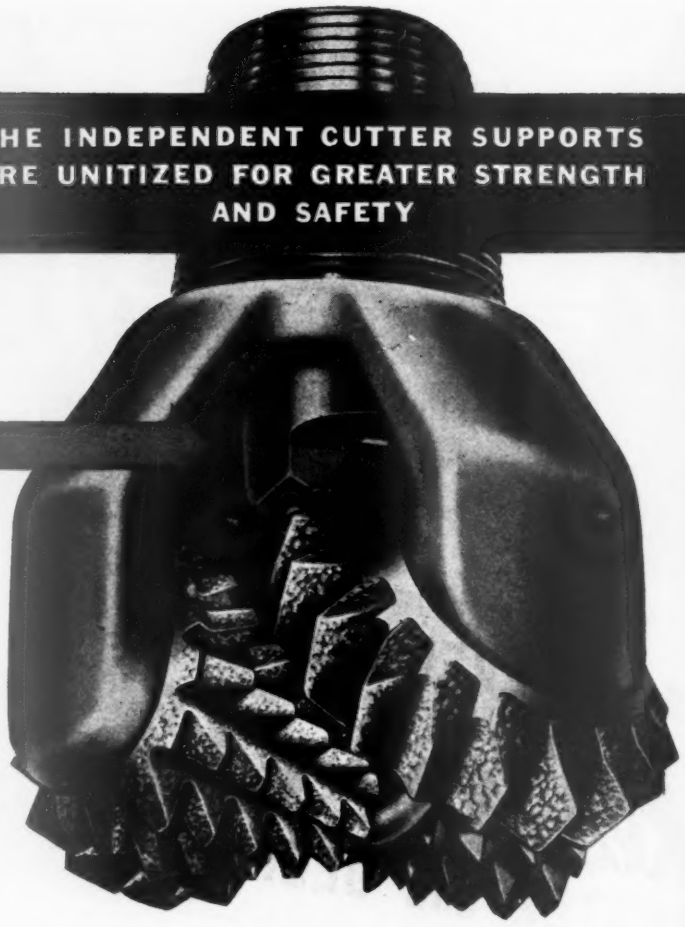
WAUKESHA
OIL FIELD POWER UNITS

THE INDEPENDENT CUTTER SUPPORTS ARE UNITIZED FOR GREATER STRENGTH AND SAFETY



REED ROCK BITS

for

FASTER DRILLING SPEEDS

and

REDUCE RIG MAINTENANCE COSTS

with

LIGHTER DRILLING WEIGHTS

There is an interchangeable Mud Nozzle with jet sizes to accommodate any circulation requirement

FOUR JET NOZZLE

SIX JET NOZZLE

NOTE THE EFFICIENT CUTTER TEETH CLEANING ACTION

Reed ROLLER BIT COMPANY

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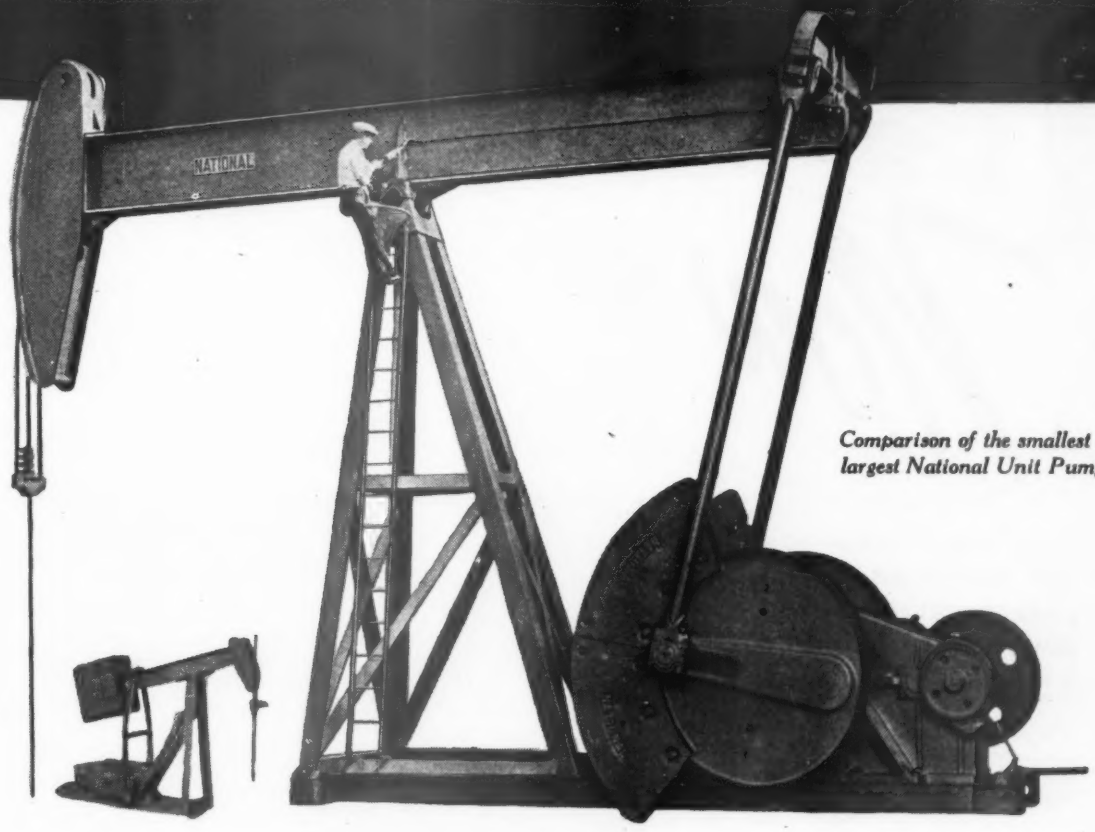
NATIONAL UNIT PUMPERS

The Choice That Dictates Pumping Profits



Comparison of the smallest and largest National Unit Pumpers

YOU can select your unit pumpers by the haphazard hit or miss method that results in the misfits that are too small or too large—too light or too heavy, or . .

You can have the counsel of a competent National Supply representative in the selection of the proper pumper to fit your individual requirements from this comprehensive line of National Unit Pumpers:

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TU-164G-HD16TP • TU-164-HD16TB • TUS-164-HD16TB

TU-234G-HD23TP • TU-234-HD23TB • TUS-234-HD23TB

TU-304-HD30TB • TU-304-H46TB • TU-304-HD46TB
TUS-304-HD30TB • TUS-304-H46TB • TUS-304-HD46TB

TU-464-H46TB • TU-464-HD46TB • TUS-464-H46TB • TUS-464-HD46TB

TU-654L-H65T • TU-654L-HD65T • TUS-654L-H65T • TUS-654L-HD65T

TU-904L-H90T • TU-904L-HD90T • TUS-904L-H90T • TUS-904L-HD90T

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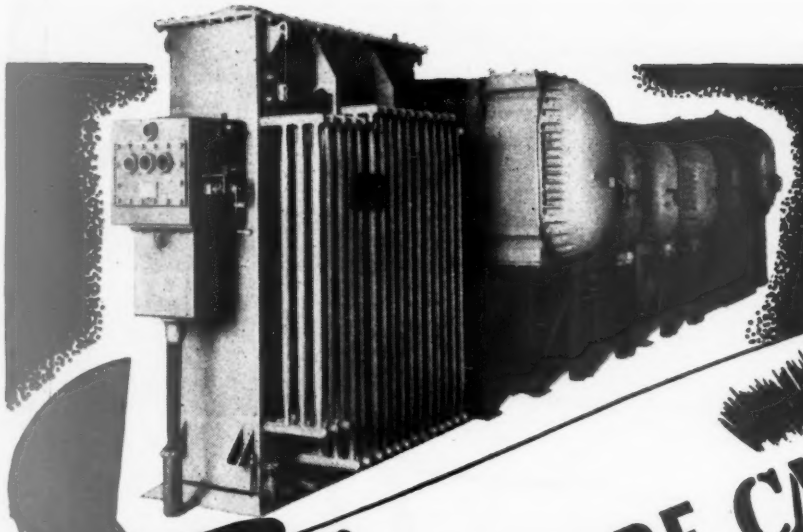
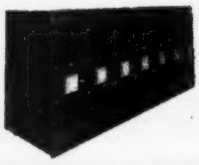


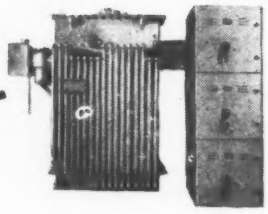
THIS G-E UNIT SUB-STATION IS DESIGNED FOR SEMI-HAZARDOUS LOCATIONS.

Now MORE CAUTION AREAS

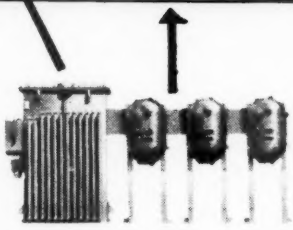
THESE CHARTS SHOW HOW G-E UNIT SUBSTATIONS CAN BE COMBINED TO MEET BOTH NORMAL AND SEMI-HAZARDOUS CONDITIONS



Vertical-lift refinery-type switchgear for corrosive and hazardous atmospheres



Standard G-E load-center unit substations



G-E load-center unit substation for semi-hazardous locations

THE *Principle* OF LOAD-CENTER POWER DISTRIBUTION

—and its advantages

Power is distributed through small cables at relatively high voltages (2.4 to 13.2 kv) to unit substations near the load centers. There it is stepped down to utilization voltages (600 volts or lower) and distributed to the load by short low-voltage feeder cables. When the load requires it, two or more small unit substations are used rather than a single, large substation.

Cable between units may be a small-size, high-voltage type. Because the smaller transformers furnish less short-circuit current, smaller air breakers can provide adequate interrupting capacity. The short secondary circuits greatly reduce voltage sag. This results in more adequate voltage at lower installation and operating costs.

Two RXIV, 8-cylinder Le Roi engines doing an outstanding job on the W. F. Cullem Drilling Rig near Wichita Falls, Texas.

The performance record of

LE ROI ENGINES

is your assurance of creditable results

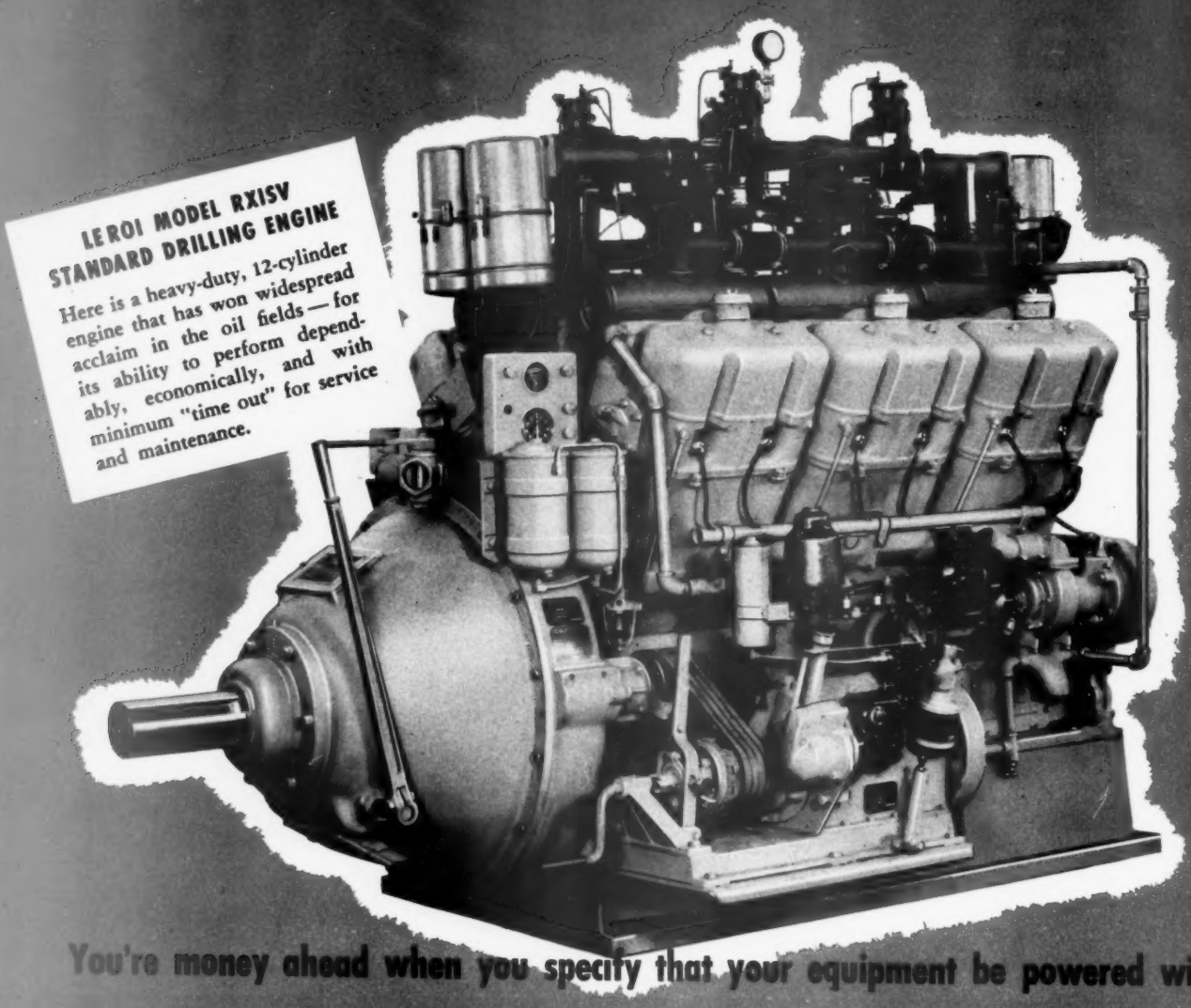
LE ROI
MILWAUKEE

Le Roi engines prove their ability to perform dependably wherever tough conditions test soundness of design and quality of workmanship and materials. There are two major reasons why: (1) Le Roi engines are built by a manufacturer specializing exclusively in the heavy-duty field. (2) Le Roi engines are designed for your specialized power requirements in each of the three main oil-field applications.

Careful engineering, based on many years of experience with oil-field conditions, has enabled Le Roi engineers to give you power units famous for steady, trouble-free service with low maintenance cost — for flashing response to pull safely through the heavy loads — and for fuel bills that are easy on costs when you "add up" at the end of a job.

Ask your nearby Le Roi distributor, who services the oil industry exclusively, to give you the complete story on Le Roi engines. Complete range of sizes to 400 H.P. Use natural gas, gasoline, or butane. Write for descriptive bulletins.

TURN THE PAGE



LE ROI MODEL RXISV STANDARD DRILLING ENGINE

Here is a heavy-duty, 12-cylinder engine that has won widespread acclaim in the oil fields — for its ability to perform dependably, economically, and with minimum "time out" for service and maintenance.

You're money ahead when you specify that your equipment be powered with

LE ROI Engines

Oil fields are no place for weaklings. It takes weight and stamina — years of experience with actual oil field conditions — careful engineering — and rugged construction to give you the low-cost, trouble-free service you must have if you are going to operate at a profit.

There is more than a quarter-century of specialized experience behind Le Roi engines. That's why they're so substantially built. You'll find they are made of fine materials, including costly alloys — machined with exceptional precision — completely equipped with modern accessories — and thoroughly inspected and tested. They're economical to operate with gasoline, natural gas, or butane — and available in a complete range of sizes from 4 to 400 H.P.

You save money all the way when you insist on Le Roi engines, because they're built for your specialized power requirement, to operate dependably and economically. Contact your nearby Le Roi distributor for full information.

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Le Roi Company Branch — Tulsa, Okla.
Carson Machine & Supply Company, Oklahoma City

EAST AND SOUTH TEXAS GULF COAST
Southern Engine & Pump Company, Houston, Kilgore, Alice and New Iberia, La.

NORTH AND WEST TEXAS
General Machine & Supply Company, Wichita Falls, Odessa

KANSAS
Carson Machine & Supply Company, Great Bend

ILLINOIS — MISSOURI
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MICHIGAN
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ROCKY MOUNTAIN AREA
Industrial Power Units, Inc. — Casper, Wyo.

NORTHERN LOUISIANA, MISSISSIPPI, and SOUTHERN ARKANSAS
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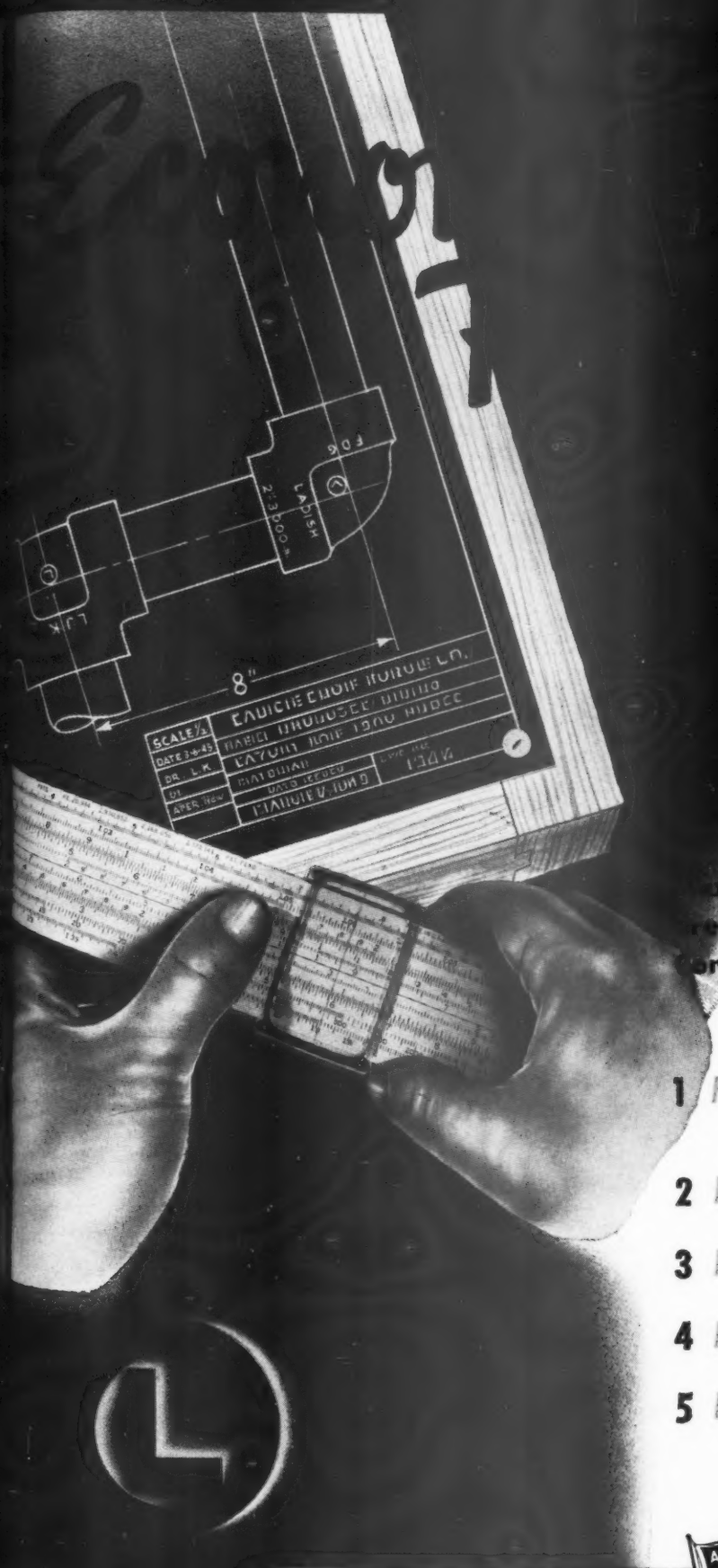

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...th and safety afforded ... forged steel fittings assure ... economy in years of trouble-free ...tion and freedom from costly piping ...s.

...ximum strength, endurance and safety ...e assured by the authentic symbol of ...ntrolled Quality, the Ladish Heat Code.

REASONS WHY

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5 *Forged* — **Fittings produced under Controlled Quality possess better properties for assured weldability.**

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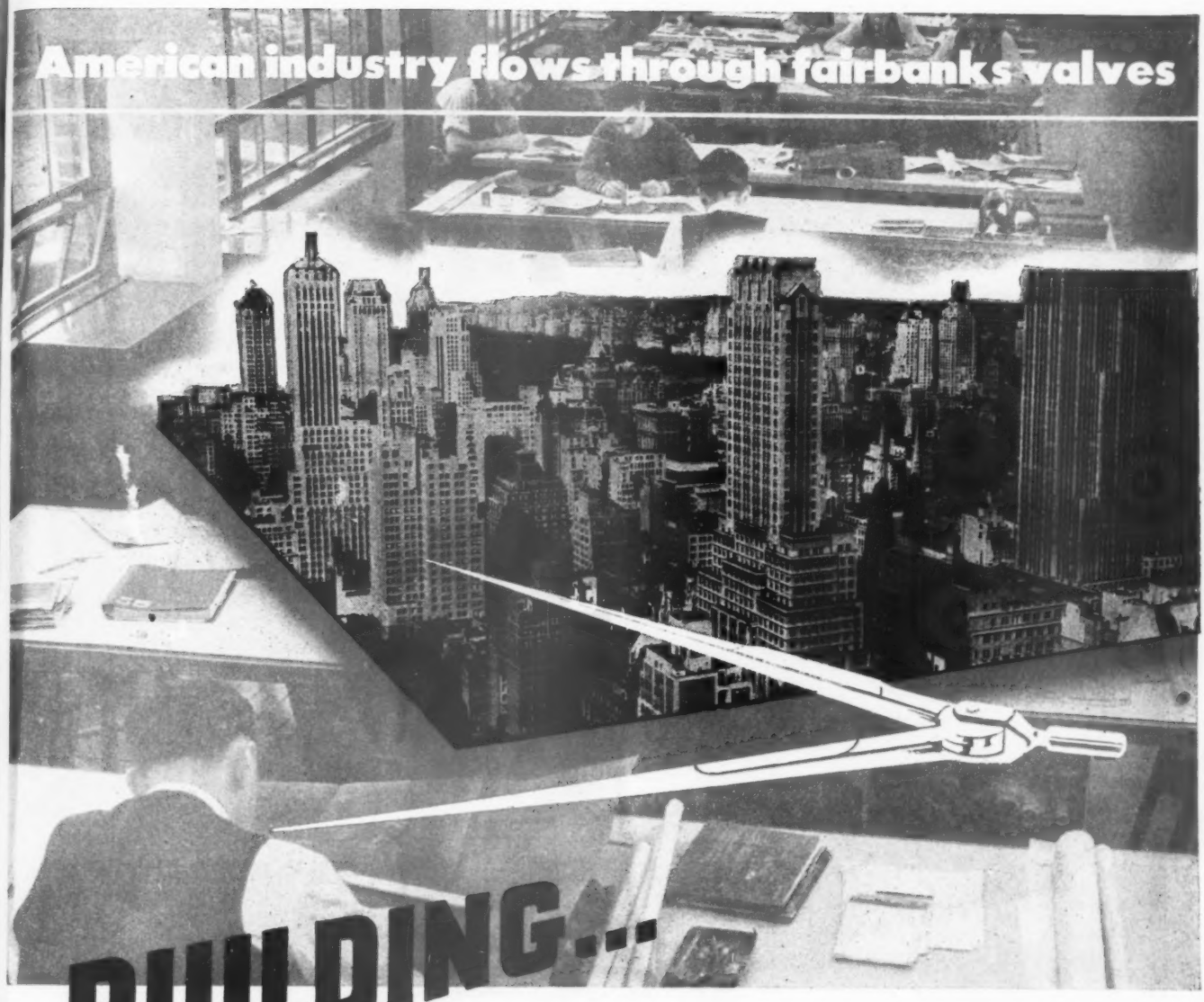
Portrait of a Pattern

OWS

The speed and footage of a rock bit depends to a large degree on the "Rock Pattern" made by the bit teeth. The bottom-hole pattern made by Hughes OWS Tricone, another Hughes specially-designed Rock Bit, provides maximum cutting action in tough formations . . . . combinations of hard rocks interstratified with waxy, tough shale beds, chalk, hard lime, dolomitic lime, hard shale, slate and dolomite.

Hughes
TOOL COMPANY
HOUSTON, TEXAS



BUILDING...

tomorrow's wakening giant

After war's final "cease-firing", look for the building industry to go places . . . for vast cities-within-cities to take shape. They're on drafting boards today.

Air conditioning and ventilating will be widened to include removal of dust, bacteria and odors from the atmosphere by unit-type air sanitation equipment. On the upswing will be radiant heating, zoned heating, service hot water, spot cooling units . . . gas air conditioning which regulates humidity . . . a single heat pump system which heats buildings or cools them as desired.

Controlling liquids and gases in miles-on-miles of tomorrow's piping will be thousands and thousands of Fairbanks Valves. They will have been selected because of topflight past performance . . . because architects and engineers know they can expect freedom from failure when a Fairbanks is installed.

Whether it's a small bronze valve or a huge iron body gate valve with a 24-inch opening the name Fairbanks stands for sound engineering, careful chemical and metallurgical control of alloys, ample metal for the job. The full line is given in catalog "42" which will be sent you if you ask for it. If you need special assistance with individual problems of valve selection and application, call on the facilities of the Fairbanks Engineering Department.

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This shows the fundamental simplicity of Hydrodyne—there are no gears, screws or other compound mechanisms. A small reversible electric motor drives the oil pump, forcing hydraulic fluid into the upper cylinder, closing the valve by straight line action. Bounce and backlash are completely eliminated.

CLOSING

Merely reversing the motor and pump forces oil into the lower end of the cylinder, opening the valve. The smooth hydraulic power can be reversed instantaneously—there is no hammer-blow action—or it can be arrested at any point for as long as desired.

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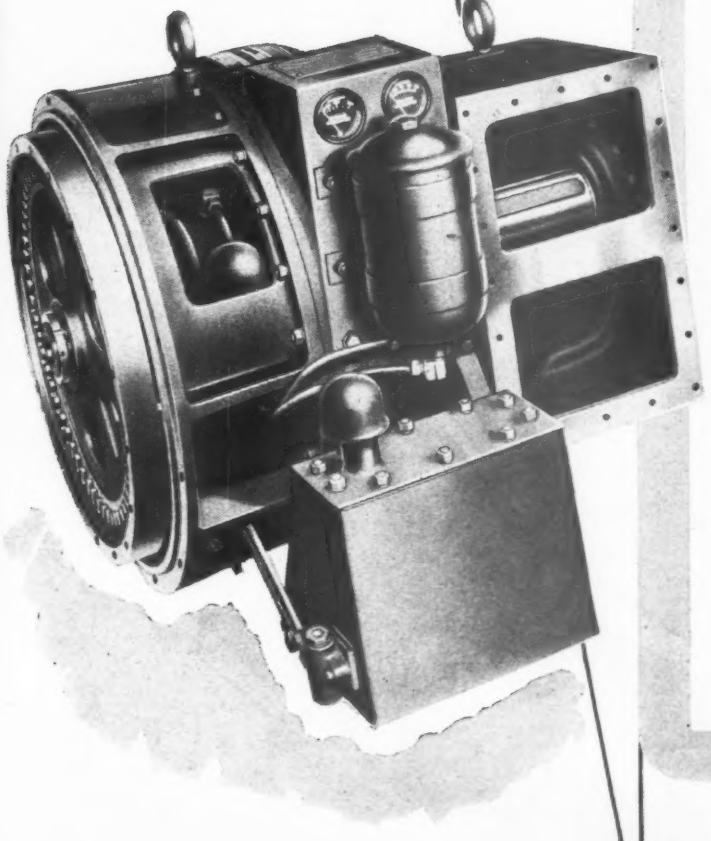
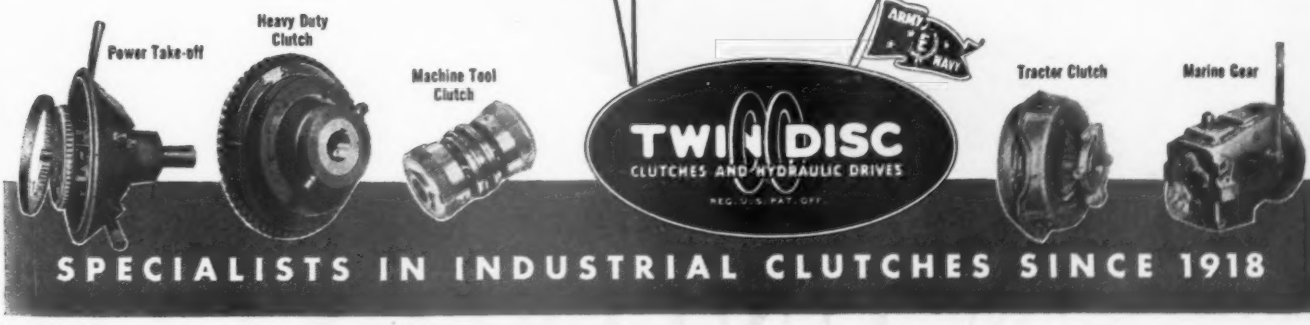
MAKES EVERY MINUTE COUNT



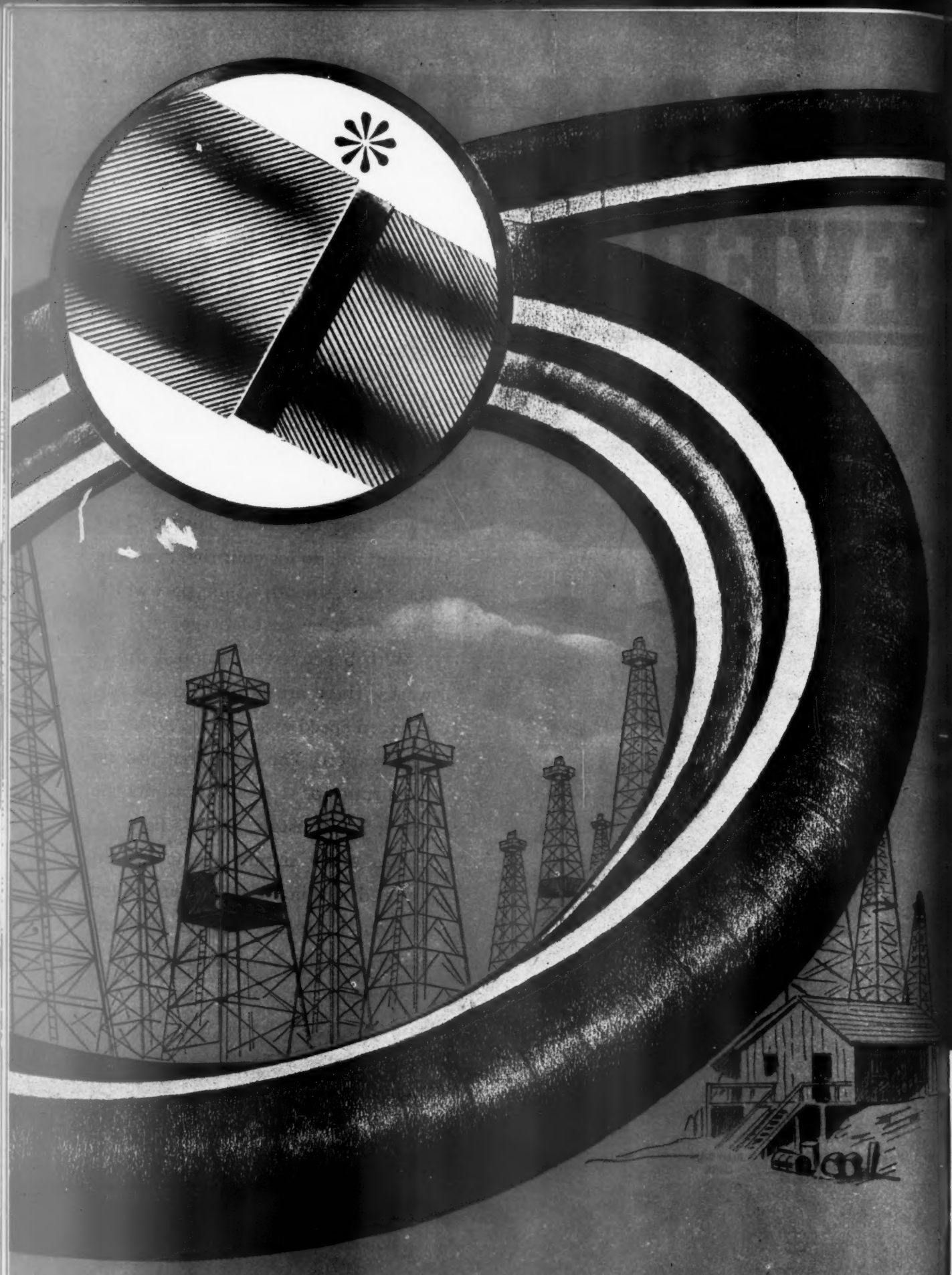
In drilling an oil well, as in running a marathon, it's the steady, unbroken pace that pays off. That's what a Twin Disc Hydraulic Torque Converter* will do for your rig . . . assure the steady, smooth drilling pace which pays off in low-cost footage.

With a converter-equipped drawworks, there are no wasted seconds between speed changes . . . no lag in acceleration. The converter has no fixed ratios or steps . . . transmits the power in a constant, endless flow . . . makes *every* minute count toward reduced drilling costs. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Div., Rockford, Ill.).

**Lysholm-Smith type*



SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918



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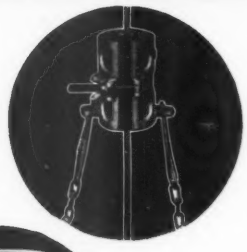
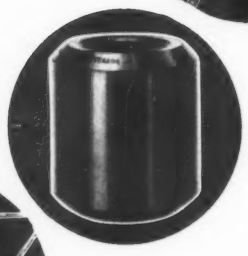
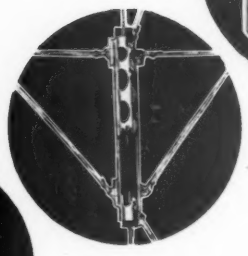


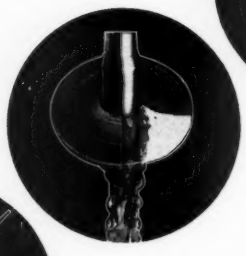
WIRE LINE WIPER



STABILIZER



6-SECTION WIRE LINE GUIDE



PIPE WIPER

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Write today for New Illustrated Catalogs

PROTECTOR

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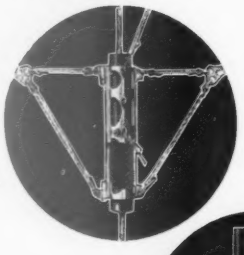
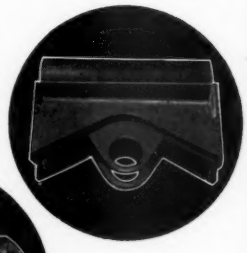
"Best Bet Yet" ... More to Come

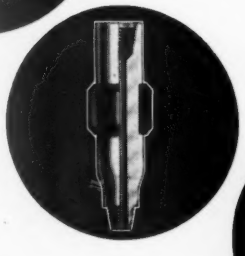
See Composite Catalog



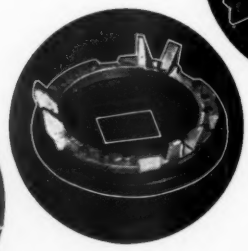
4-SECTION WIRE LINE GUIDE



TRAVELING BLOCK BUMPER

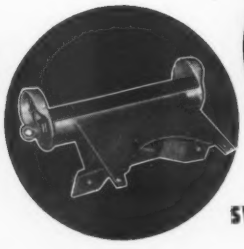


KELLY SUB PROTECTOR



KELLY WIPER

DEAD LINE STABILIZER



SWIVEL BAIL BUMPER

MORE SERVICE ON ROTARY TABLE DRIVES

HELMERICH & PAYNE, INC.
415 PHILTOWER
TULSA, OKLAHOMA

January 15, 1945

Diamond Chain & Mfg. Company,
Tulsa, Oklahoma

Attention: Mr. John Wamsley

Gentlemen:

At the present time we have 19 Wilson rigs in operation.

About two years ago we equipped our first rig with Diamond finished roller chain on our rotary drive, to which I would like to call your attention. This particular chain was put on when we started a well in West Texas, which drilled to a total depth of 9592 feet in 238 days; then the rig was moved to another well and drilled to 8616 feet in 102 days; then moved to another well and drilled to 2610 feet in 42 days; making a total of 20,818 feet in 382 days before this chain was taken off and changed, giving us much more service than any other make of chain or the ordinary old-style rotary chain. This was a Diamond finished roller chain. We are now changing all our big rigs to this type rotary drive, and buying all our new rigs equipped with this particular kind of chain, which has performed so efficiently.

It would be impossible for us to estimate the number of chains of the old-style necessary to drill this amount of hole or run 382 days without using this chain which we found to be satisfactory on its first trial. Not only do we get better service out of a Diamond roller chain on our rotary drive, but it has several other advantages such as running more quietly and smoothly and, also, saving wear and tear on the Kelly, Kelly Bushings and Rotary Table.

Yours very truly,

Helmerich & Payne, Inc.

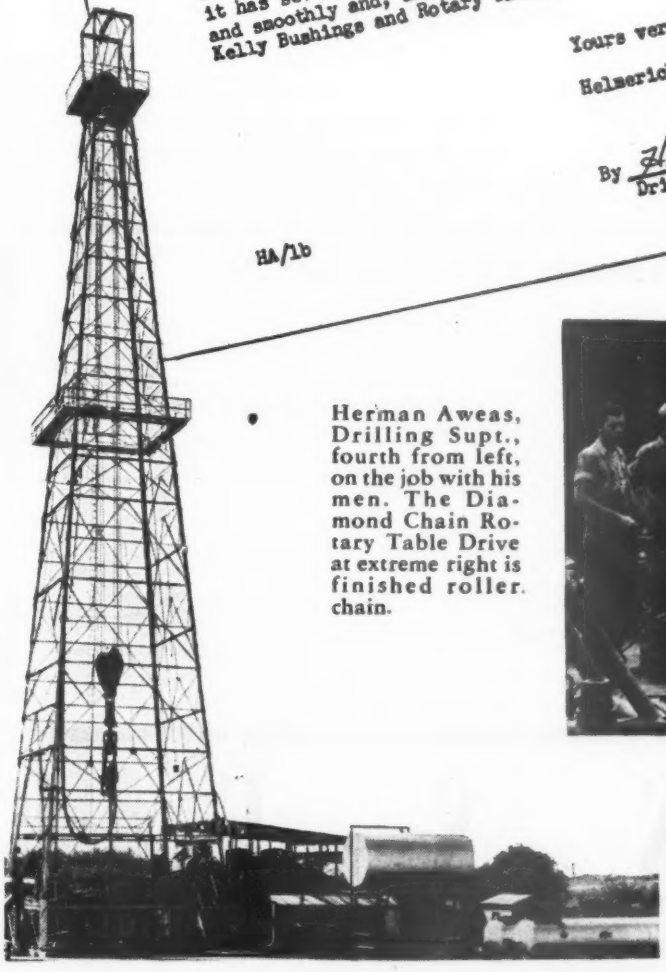
By Herman Aweas
Drilling Superintendent

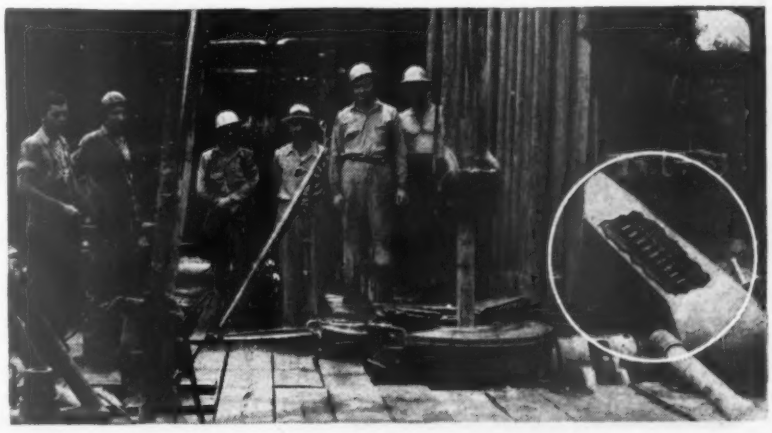
HA/lb

with Diamond Roller Chains Than with Any Other Make or Type of Chain

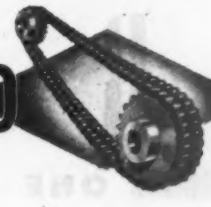
"On the rig we equipped with Diamond finished Roller Chain on rotary table two years ago, 20,818 feet were drilled in 382 days—more than with any other make or type of chain. We are now changing all our big rigs to this type rotary drive."

That's the experience of Helmerich & Payne, Inc as reported by Mr. Herman Aweas, Drilling Supt. And note the last four lines of his letter for further very important advantages. DIAMOND CHAIN & MFG. CO., 441 Kentucky Avenue, Indianapolis 7, Indiana. Tulsa Office: 2238 Terwilleger Boulevard.





Herman Aweas, Drilling Supt., fourth from left, on the job with his men. The Diamond Chain Rotary Table Drive at extreme right is finished roller chain.



DIAMOND ROLLER CHAINS

Avoid HARMFUL STRESS AND STRAIN

in machinery settings and connections

. . . with Dresser Couplings

Pipe connections to pumps, mechanical blowers and other vibrating or reciprocating machinery are usually subject to harmful stresses and strains caused by misalignment, expansion and contraction, operational vibration—or sudden shock—which may damage conventional pipe-flange connections. A flange failure often necessitates replacement of pipe sections—with consequent shutdown for repairs.

By installing flexible Dresser Couplings at pump and valve flange joints, for example, such failures are eliminated. Installed at inlet and at outlet (see Figure 1), Dresser Couplings protect both pump and pipe flanges from fatigue failure. The flexibility of Dresser Couplings also permits full initial tightening of flange bolts in any condensed piping system . . . with no accumulation of harmful stresses and strains.

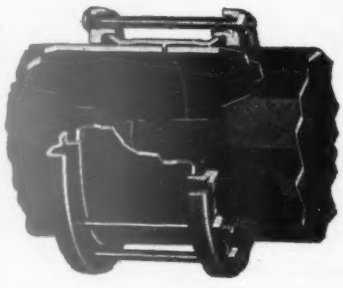
Dresser Couplings absorb the slight misalignment, vibrational movement and longitudinal movement due to expansion and contraction of pipe. Result: long, trouble-free service for the entire system.

Figures 2, 3 and 4 on the opposite page illustrate this application of flexible Dresser Couplings. These are only a few examples of how Dresser Couplings are used in making stress-proof pipe joints. For help in this or any other pipe joining problem, send us your inquiries.

* * *

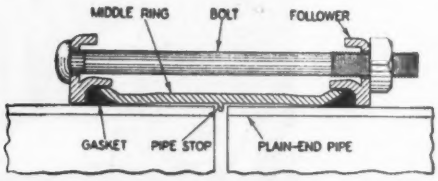
DRESSER MANUFACTURING DIVISION
Bradford, Pennsylvania
In Texas: 1121 Rothwell Street, Sec. 16, Houston, Texas
In Canada: Dresser Manufacturing Co., Ltd.,
60 Front Street, West, Toronto, Ontario.

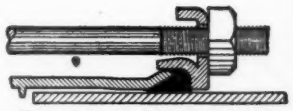
Here's Why Dresser Couplings Absorb Vibration and Stay Tight



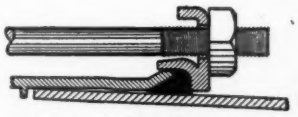
The cutaway at left and cross section below show the simplicity of Dresser construction. Dresser Couplings stay tight for life because any axial or longitudinal stresses that would normally be destructive, are absorbed by the resilient gasket seal which permits 4 degrees or more deflection (depending on diameter) and 3/8 inch longitudinal movement per coupling. (Illustrated at right.)

This simple construction—the few interchangeable parts which can be assembled only in one way—assures correct installation.





Pipe in straight position



Pipe in deflected position

D R E S S E R

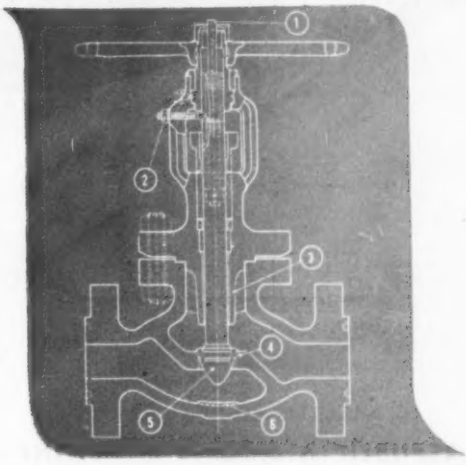
ONE OF THE DRESSER INDUSTRIES

HOW EDWARD ENGINEERING LICKED THE THROTTLER VALVE PROBLEM FOR ONE COMPANY....

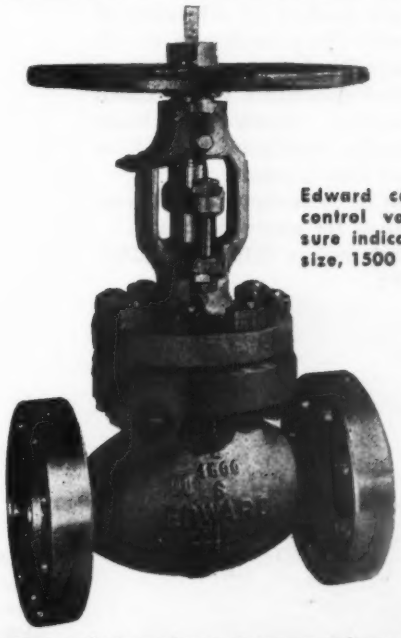
PROBLEM: Valves for throttling service have always been tough to build. The punishing wear of partly-open operation takes its toll on even the best standard globe type valve, and of course a gate valve in throttling service is seldom satisfactory. Not long ago a large Eastern utility came to Edward with a request for a valve specifically built for severe throttling service. Edward engineers, working with the customer, produced the valves described below. Originally designed for use on a feedwater pump by-pass line, they are ideally adapted to general throttling service.

Here's what happens to even high quality valve parts in the most difficult type of throttling service. Notice how fluid, at high pressures and high velocities, has cut away the metal of the disk.

SOLUTION: Here is a valve with all the features that are important in throttling. An indicator **(1)** attached to the stem shows position of the disk at all times. An Alemite fitting **(2)** eases operation. A long stem guide **(3)** keeps the stem and disk in perfect alignment at all times. The seat **(4)** is a heavy layer of Stellite, applied directly to the valve body, and the disk **(5)** parabolic in design for volume control and integral with the stem, has Stellited seating faces, too. A bearing surface of EVinlay **(6)** on the valve body gives additional protection against high velocity flow. It is recommended that the valve be installed with pressure over the disk.



RESULT: The ideal steel valves for many types of throttling service. And, for other conditions and for various sizes of lines, Edward has solved the throttling valve problem with special materials and designs. This Edward engineering experience is yours to command.

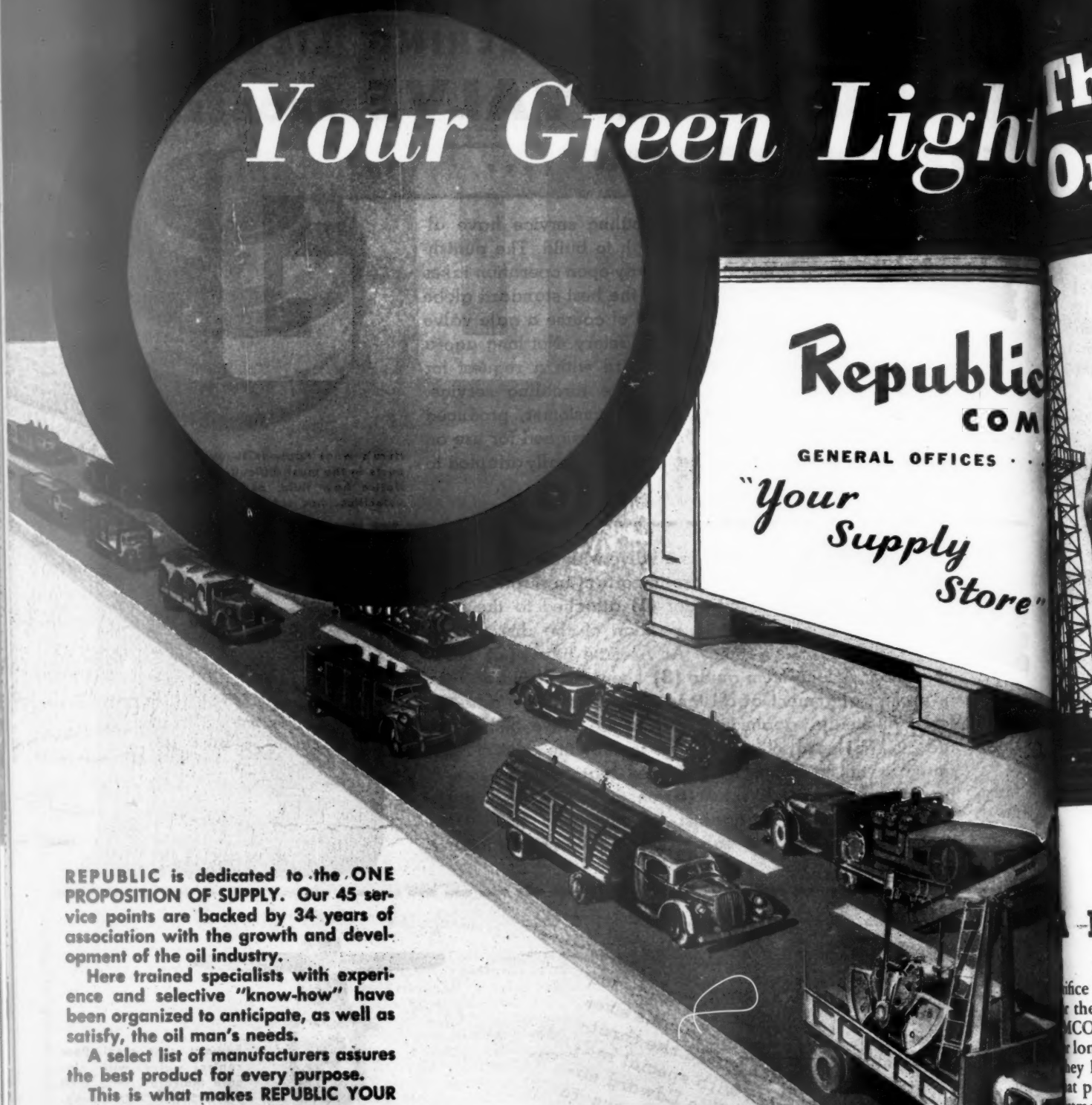


Edward cast steel flow control valve with closure indicator, in 2 inch size, 1500 lb ASA rating.

EDWARD *Steel* VALVES
THE EDWARD VALVE & MFG. CO., INC.
EAST CHICAGO, INDIANA

Look to Edward for the Best in New Steel Valve Developments

Your Green Light



REPUBLIC is dedicated to the ONE PROPOSITION OF SUPPLY. Our 45 service points are backed by 34 years of association with the growth and development of the oil industry.

Here trained specialists with experience and selective "know-how" have been organized to anticipate, as well as satisfy, the oil man's needs.

A select list of manufacturers assures the best product for every purpose.

This is what makes REPUBLIC YOUR SUPPLY STORE.

REPUBLIC SALES AND SERVICE POINTS

ARKANSAS—Camden, El Dorado, Patmos; ILLINOIS—Chicago, McLeansboro, Salem; INDIANA—Griffin; KANSAS—Ellinwood, Russell, Wichita**; LOUISIANA—Haynesville, New Iberia, Rodessa, Shreveport*; MISSISSIPPI—Jackson, Natchez***; NEW MEXICO—Hobbs; OKLAHOMA—Oklahoma City, Seminole, Tulsa**; TEXAS—Alice, Big Spring, Borger, Corpus Christi, Dallas**, Electra, Falfurrias, Fort Worth**, Hebbronville, Houston*, Kenedy, Kermit, Kilgore, Nocona, McAllen, Monahans, Odessa*, Olney, Pampa, San Antonio**, Sundown, Talco, Victoria, Wichita Falls***

* District offices and stores.
** Sales Office
*** Pipe Depot.

The EMCO Orifice Gauge

Interior view of EMCO Type 38 Orifice Meter Case

A FIELD MAN'S METER

Field measurement men are in the best position to judge rifice meter performance. They are among the strongest boosters r the EMCO design. Field men appreciate the tough, rugged MCO construction that permits these meters to stay "on stream" r long periods of time with a minimum of mechanical attention. hey like the clean-cut simplified arrangement of working parts at provides ease in handling periodic field inspections and ad- stments. When changing charts, they note the clear, legible cords left by static and differential pens. They value the engi- eering forethought that permits necessary field maintenance ork to be accomplished with the simplest of tools.

Yes, the EMCO Orifice Meter was designed by and for actical field measurement men. With extreme accuracy an complished fact, the savings in maintenance time and expense ill quickly demonstrate the marked superiority of these meters service. Ask for Bulletin 1050.

Improve Accuracy, SPEED UP CHART COMPUTATION WITH THE EMCO-McGAUGHY INTEGRATOR...

An office machine that furnishes the *exact* calculation of the extension of orifice meter charts. Assures that the accurate record made by the orifice gauge will be converted into accurate totals. Removes all doubt from orifice chart computations by providing machine precision, with verified records of results. One machine will handle the duties of a number of inspection chart readers and release this personnel for more urgent war-time work.

PITTSBURGH EQUITABLE METER COMPANY

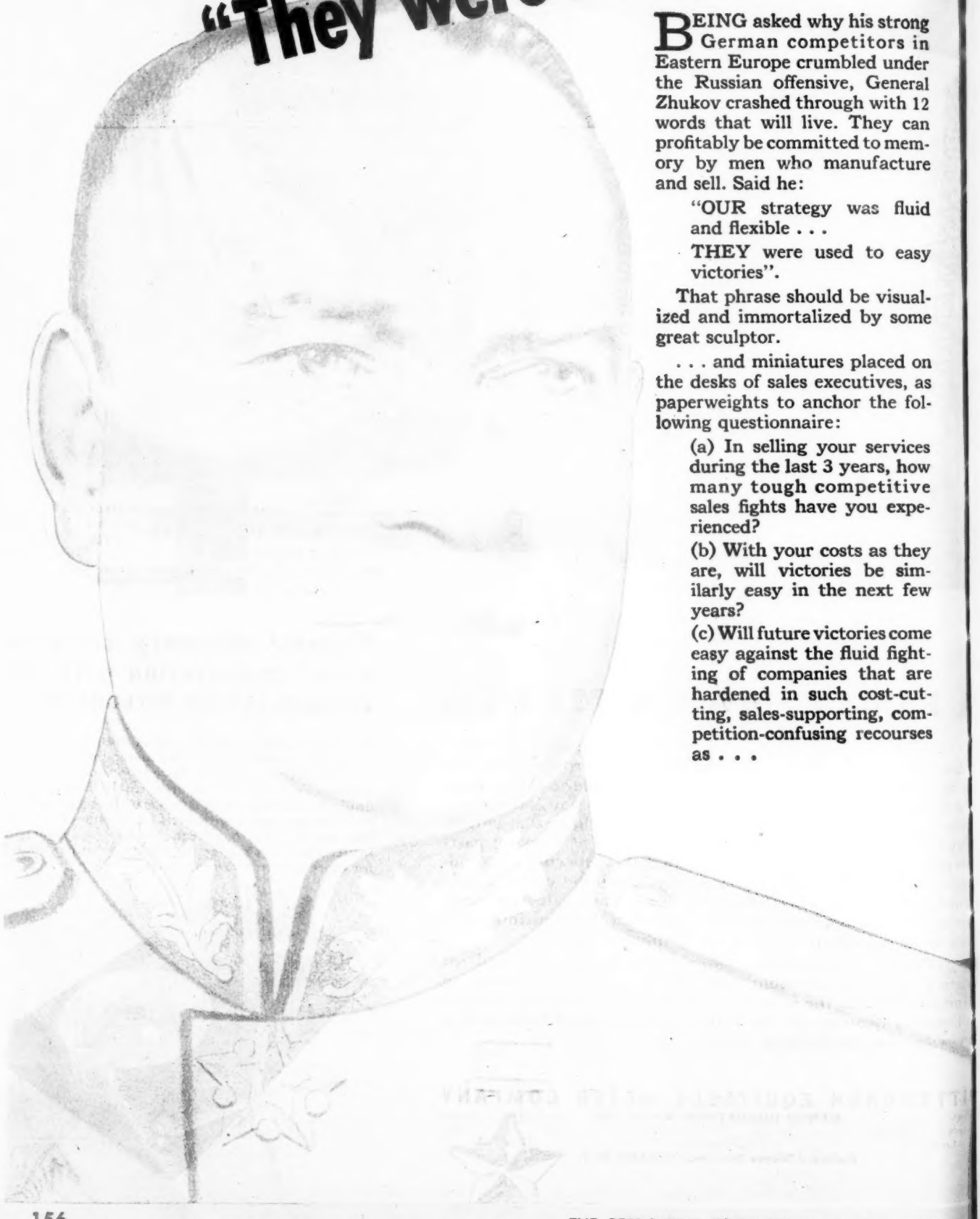
lanta Houston **MERCO NORDSTROM VALVE CO.** Los Angeles Boston
hicago Pittsburgh Main Offices, PITTSBURGH, PA. Tulsa Seattle
Kansas City San Francisco New York

National Meter Division, Brooklyn, N. Y.

DESIGNED BY AND FOR PRACTICAL FIELD MEASUREMENT MEN

then he said to himself

"They were Putschovers"



BEING asked why his strong German competitors in Eastern Europe crumbled under the Russian offensive, General Zhukov crashed through with 12 words that will live. They can profitably be committed to memory by men who manufacture and sell. Said he:

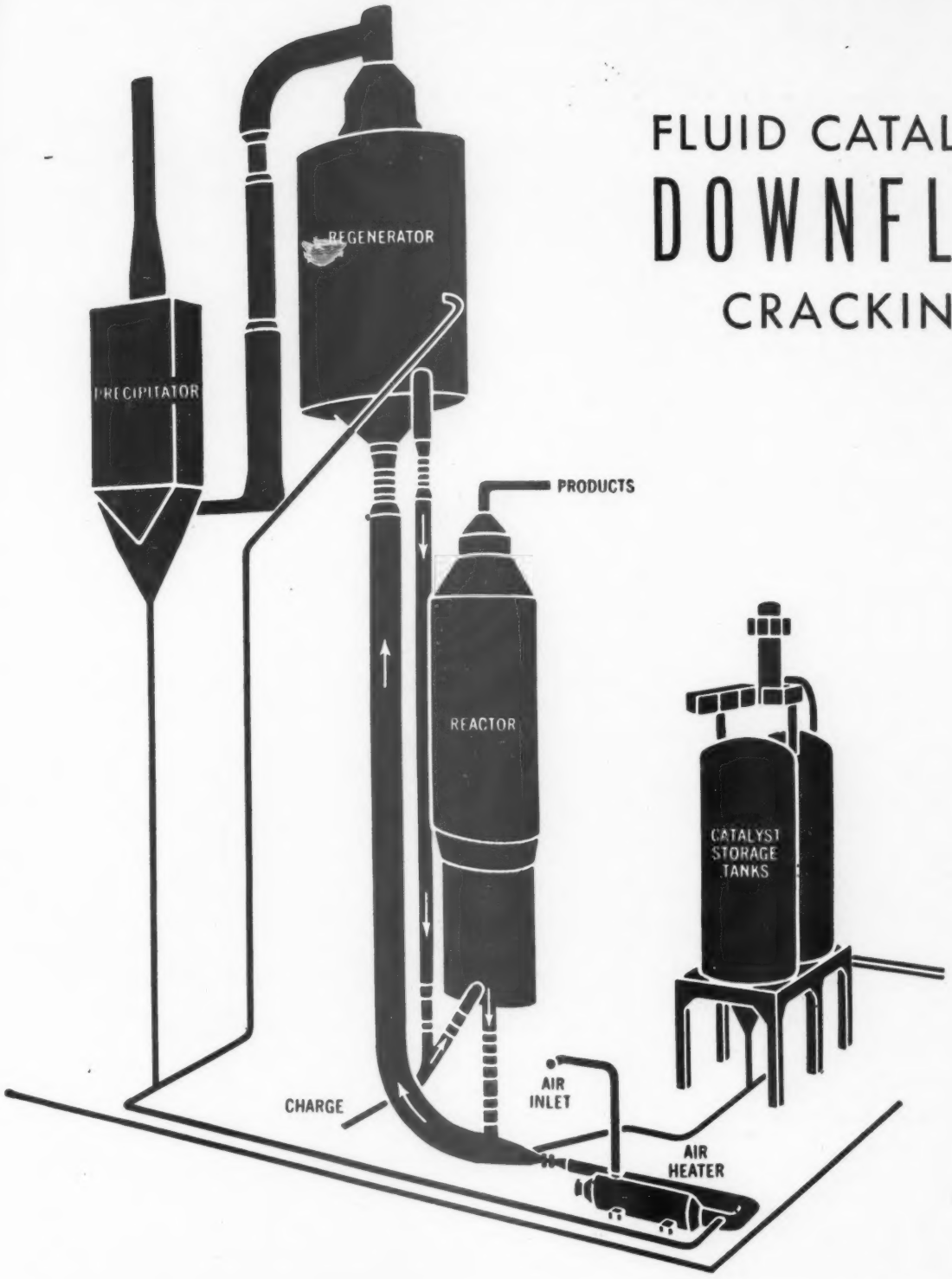
> "OUR strategy was fluid and flexible . . .
>
> THEY were used to easy victories".

That phrase should be visualized and immortalized by some great sculptor.

. . . and miniatures placed on the desks of sales executives, as paperweights to anchor the following questionnaire:

> (a) In selling your services during the last 3 years, how many tough competitive sales fights have you experienced?
>
> (b) With your costs as they are, will victories be similarly easy in the next few years?
>
> (c) Will future victories come easy against the fluid fighting of companies that are hardened in such cost-cutting, sales-supporting, competition-confusing recourses as . . .

FLUID CATALYTIC DOWNFLOW CRACKING



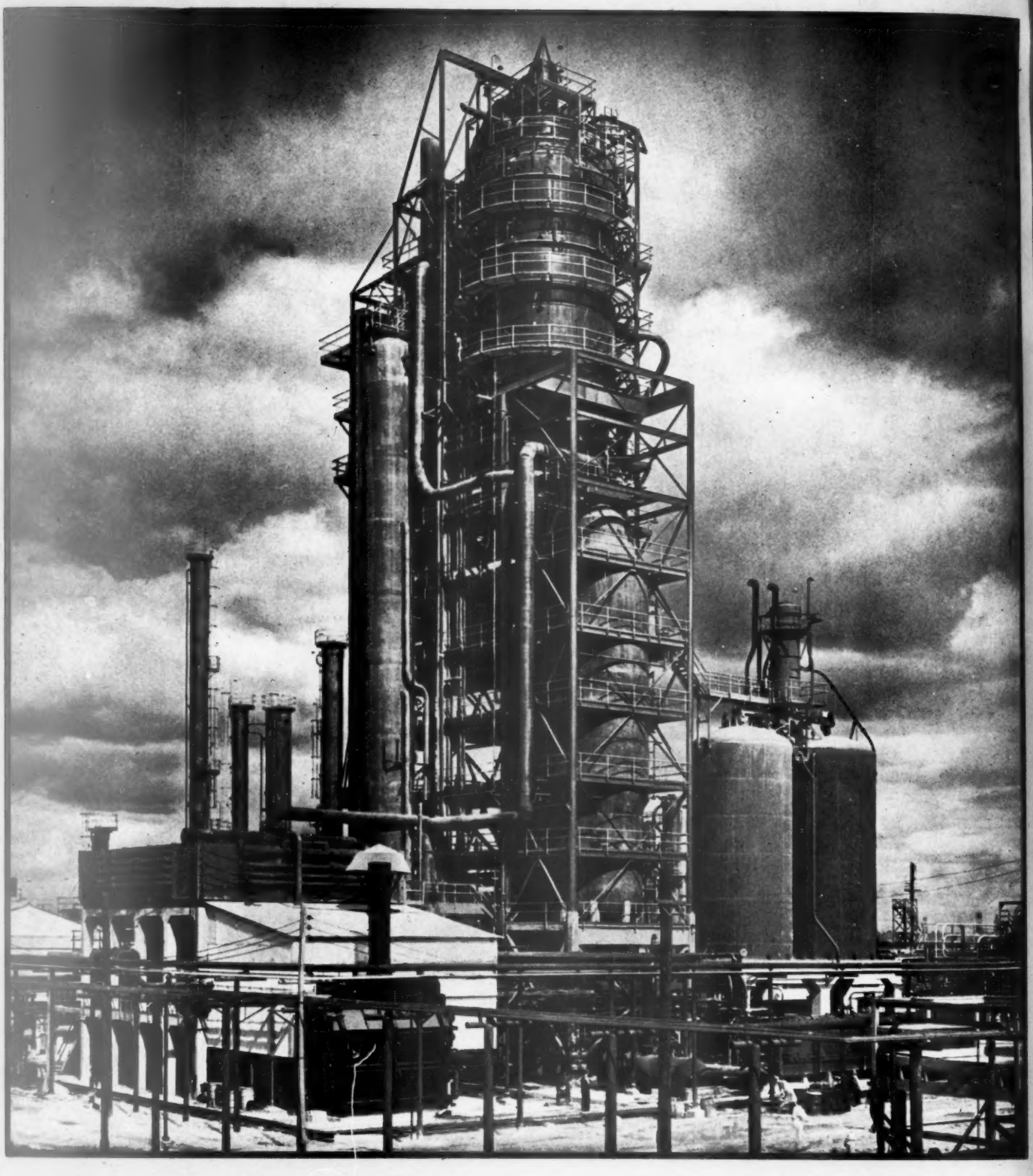
Cost per gallon of Gasoline (of comparable Octane) is the only true measure of the overall efficiency of a cracking process.

Octanes (as high as 99.8 Research)—Charges (as heavy as 90% at 1065°F.)—"Onstream" (as long as 6 months) are operating accomplishments which classify FLUID CATALYTIC "DOWNFLOW" CRACKING as the most economic method for producing HIGH OCTANE MOTOR GASOLINE.

Reprints of the technical description and advantages of this improved catalyst flow, titled "IMPROVED FLUID PROCESS FOR CATALYTIC CRACKING" by E.V. Murphree et al (presented at the November 1944 meeting of the A.I.Ch.E.) are available on request. Address Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.

FOSTER WHEELER

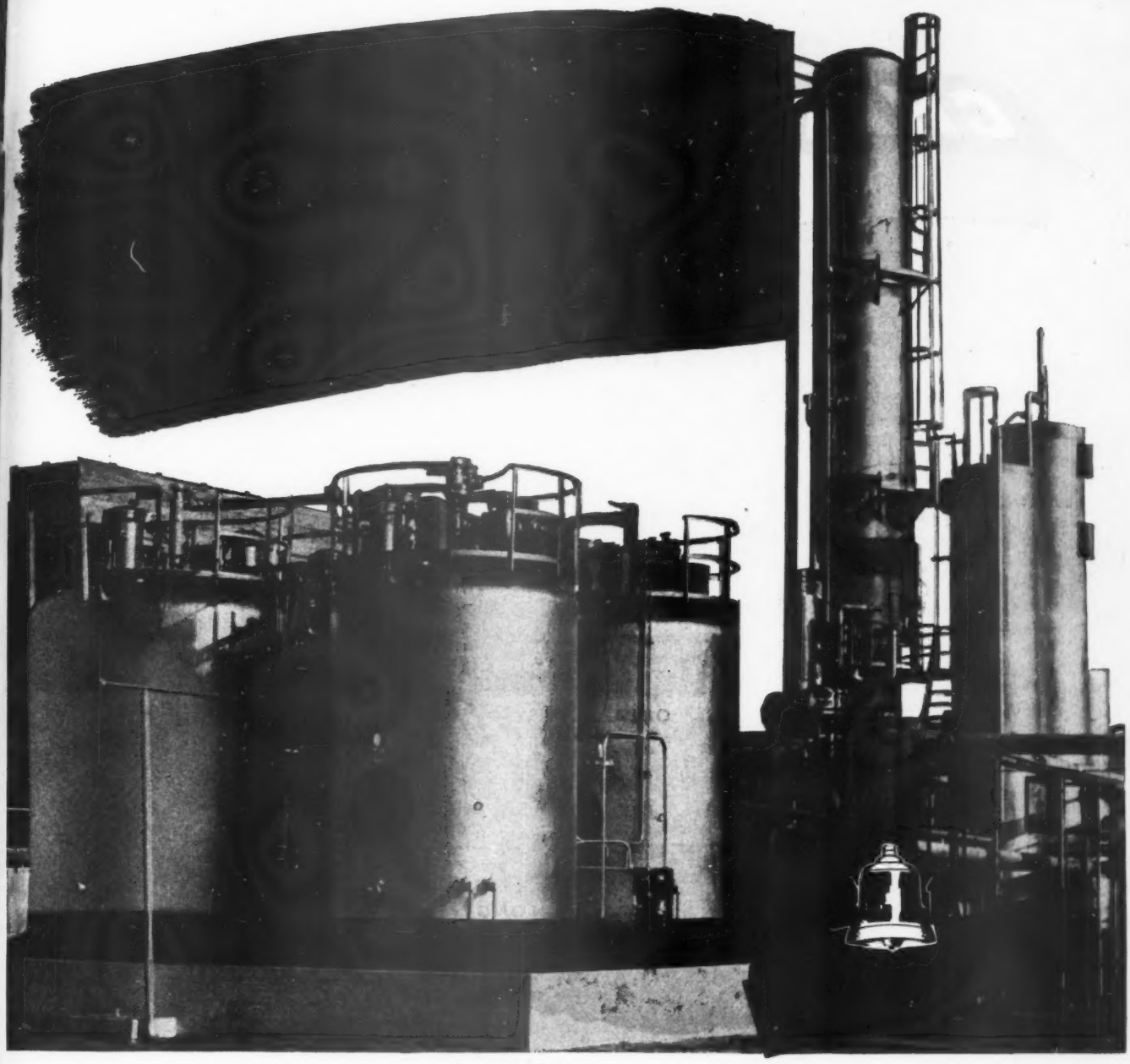
"Octane Independence"



Octane competition is no problem to a refiner using FLUID CATALYTIC CRACKING. Performance records covering a wide variety of operating procedure represent substantial proof, that a "FLUID" unit can place a refiner in that desirable manufacturing position of being able to meet any competitive Octane situation.

FOSTER WHEELER CORPORATION

165 Broadway, New York 6, N. Y.



● Petreco's record of successfully desalting crude oils within a gravity range of 18 to 40° API is well established but the above plant is the first installation to desalt 15° API crude.

This four unit desalter is located at Santa Maria, California, and processes Santa Maria Valley crude.

This offers another example of the flexibility of the Petreco desalting process. It is designed to handle crudes of varying characteristics and within high and low gravity ranges.

PETROLEUM RECTIFYING COMPANY
5121 So. Wayside Dr., Houston 1, Texas
530 West Sixth Street, Los Angeles 14, Calif
648 Edison Building, Toledo 4, Ohio
Representatives in principal production and refining centers

PETRECO

Desalting • *Electrical Process* • Dehydrating

SHAFER "DE" 22000 Bearings

The Self-Contained, Self-Aligning Self-Centering ROLLER BEARING with *Raceways like a Ball*

The secret of superior bearing performance is found when you combine the self-aligning, self-centering characteristics of a ball with the load carrying characteristics of a roller. The secret of superior bearing performance is *yours* when you specify Shafer ConCaVex Self-Aligning Bearings. Only Shafer *patents* make possible the exclusive advantages of the ball and roller combination in their construction. This unique principle was created by Shafer a quarter of a century ago and to date it has established bearing performance records thousands of users claim have no equal. Only bearings of the Shafer basic design are inherently immune to end and radial thrust, to misalignment and shaft deflection, to load shocks.

Ask the men who use them. SHAFER BEARING CORPORATION, 1426 West Washington Blvd., Chicago 7, Illinois.

1. SHAFER "DE" 22000 SERIES
The self-contained bearing, preadjusted, ready to install. Has one piece outer race, two rows of rollers and single inner race for compactness. Maximum capacity.

2. SHAFER DOUBLE ROW BEARING ASSEMBLY
for building into machines, power transmission equipment, etc. Two outer races, two roller assemblies. A single inner race.

3. SHAFER SINGLE ROW BEARING ASSEMBLIES
One outer race, one row of rollers, one inner race. Self-aligning with radial and thrust load capacity.

CONCAVEX

Reg. U. S. Pat. Off.

FLIES GET STUCK..

...SO DO UNLUBRICATED VALVES

But NORDSTROM VALVES

turn easily Forever

THEY'RE LUBRICATED

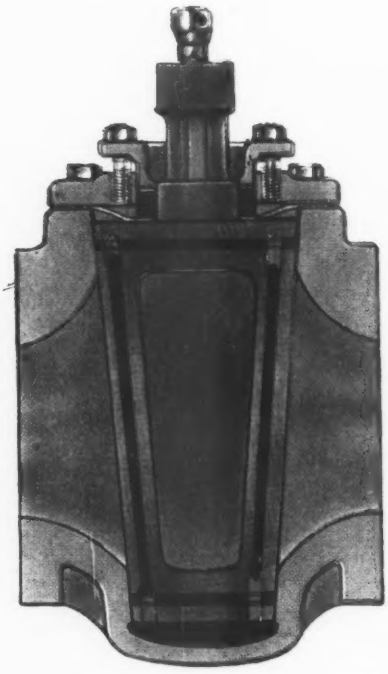
The valves with

POSITIVE ROTARY ACTION

—port sealed with pressure lubricant

Nordstrom Lubricated Valves are built on the tapered rotary principle. It is the simplest and most positive valve action known. The taper of the plug and seat maintains an intimate working contact between the two parts at all times. Since the valve is opened and closed by rotation only, and *not* by raising or lowering the movable valve member, the vital seating surfaces are self-protecting and self-cleaning. There are no pockets or recesses to collect sediment or scale deposits.

A stick of Nordco Lubricant, inserted in the shank of the plug, keeps the Nordstrom Valve in prime condition. It gives the vital lubrication required for long life, perfect sealing and easy turning of plug.



"Sealdport" grooves completely surround closed ports. In the above illustration the yellow areas indicate "tail" grooves in the body which connect with the vertical lubricant grooves in the plug, to form an unbroken circuit of pressure, regardless of position of the plug.

Full circumferential grooves are provided above and below ports. Lubricant enters unexposed long grooves in plug which lead directly to jacking chamber under plug. A few turns of the lubricant screw at top of plug forces lubricant through the grooves and lifts plug, if overly tight.

Basic sealing principle in all Nordstrom Valves

The details of groove arrangements vary somewhat in different styles of Nordstrom Valves. However, all of the systems have two things in common—supply of a complete film around closed ports and cut-offs of any exposed portions of the grooves. The vital need for lubricant is evident. No *un*lubricated valve can offer such a positive seal against leakage or equal certainty of easy turning. Nordstrom engineering principles insure most efficient operation regardless of conditions.

KEEP UPKEEP DOWN

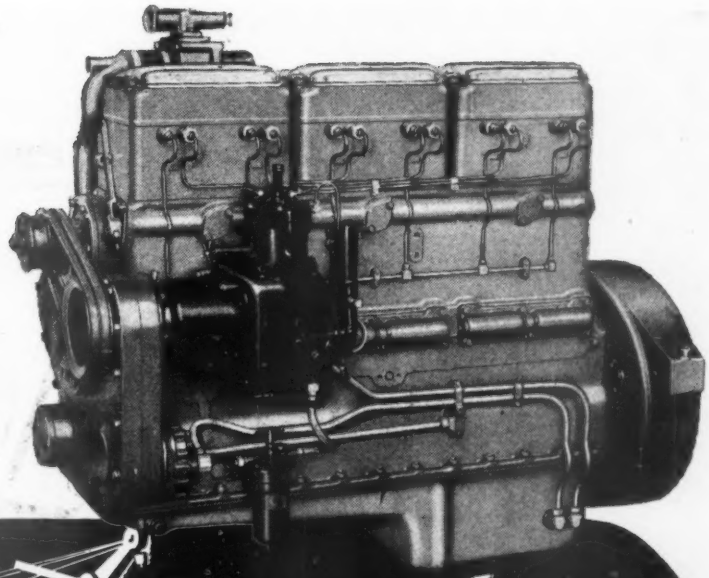
Nordstrom LUBRICATED VALVES

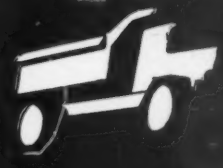
Sealdport Lubrication

MERCO NORDSTROM VALVE COMPANY—*A Subsidiary of Pittsburgh Equitable Meter Company*

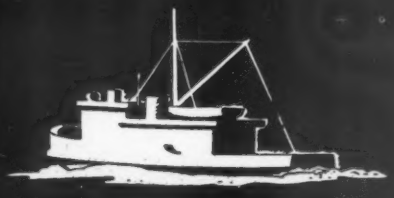
Main Offices: 400 Lexington Avenue, Pittsburgh 8, Penna. • *Branches:* Atlanta, Boston, Brooklyn, Buffalo, Chicago, Columbia, Houston, Kansas City, Los Angeles, New York City, Oakland, San Francisco, Seattle, Tulsa • *Canadian Licensees:* Peacock Bros., Ltd., Montreal
European Licensees: Audley Engineering Co., Ltd., Newport, Shropshire, England • *South American Representative:* The Armco Int'l Corp. • *Main Office:* Middletown, O.
PRODUCTS: Nordstrom Lubricated Valves; Air, Curb and Meter Cocks • Nordco Valve Lubricants • EMCO Gas Meters • EMCO-McGaughy Integrators
EMCO Regulators • Pittsburgh-National Meters for Gasoline, Grease, Oil, Water and other Liquids • Stupakoff Bottom Hole Gauges

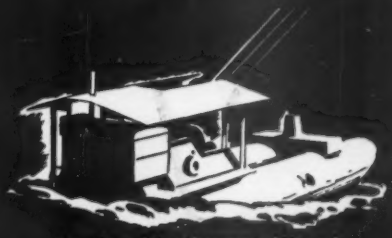
Jobs for PROVED POWER are jobs for CUMMINS DIESELS





Any list of the nation's major contractors is a list of Cummins Diesel owners. Their records prove that . . . "powered by Cummins is powered for profit."



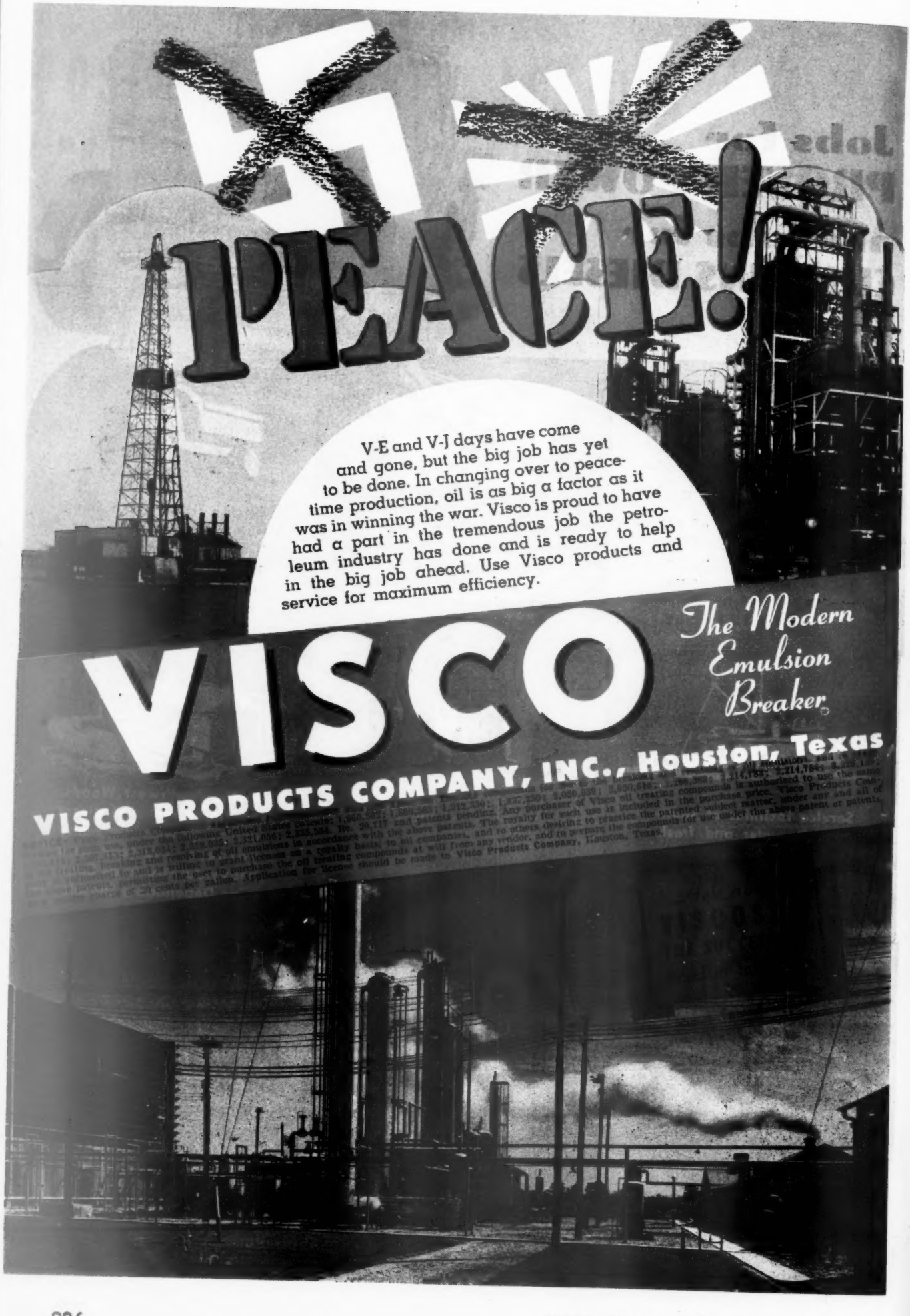


Service facilities at some 40 salt water and fresh water ports . . . one more reason why so many commercial and pleasure craft are Cummins-powered.

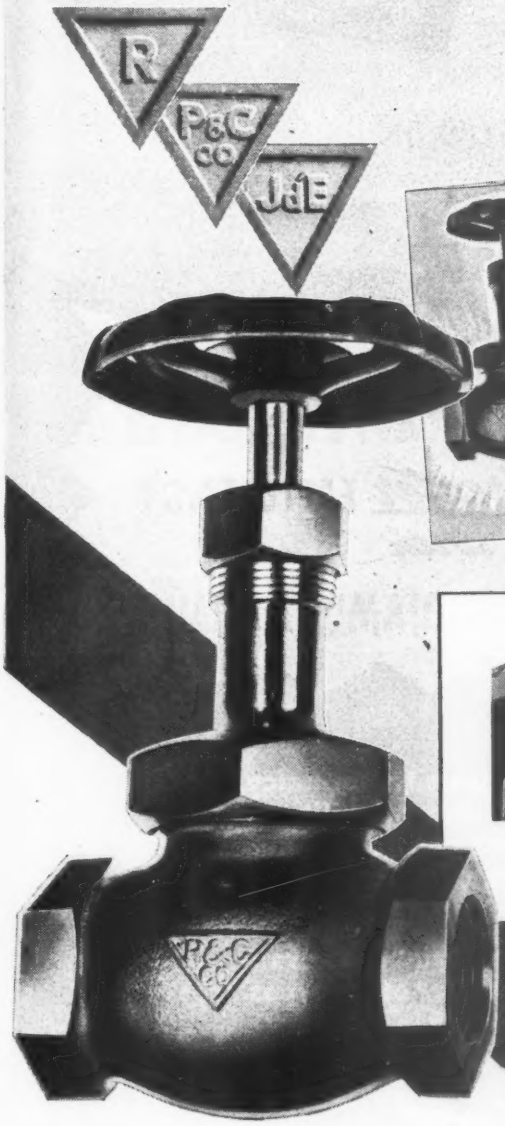
In the Northwest Woods, no single make of diesel engine powers as many yarders, loaders and heavy-duty trucks as Cummins Dependable Diesels.

CUMMINS DIESELS

SINCE 1918...PIONEER OF PROFITABLE POWER THROUGH HIGH SPEED DIESELS

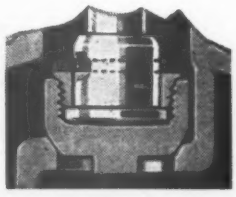

PEACE!
V-E and V-J days have come and gone, but the big job has yet to be done. In changing over to peacetime production, oil is as big a factor as it was in winning the war. Visco is proud to have had a part in the tremendous job the petroleum industry has done and is ready to help in the big job ahead. Use Visco products and service for maximum efficiency.
VISCO
The Modern Emulsion Breaker
VISCO PRODUCTS COMPANY, INC., Houston, Texas

WHERE *Higher* QUALITY MEANS *Lower* ULTIMATE COST

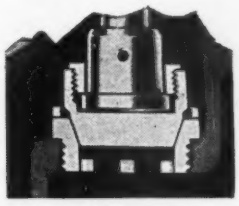


● It's a matter of simple arithmetic. If one valve costs two-thirds more than another and lasts eight times as long in the same service—naturally it's a better buy. That is the principle on which this line of superlative bronze valves is engineered.

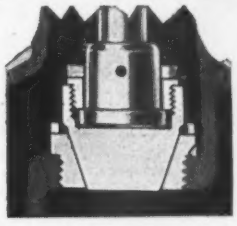
We suggest you send for this file-size folder of information about PRATT & CADY bronze globe and angle valves. The page on "Dollars and Sense of Valve Service" is worthwhile reading for anyone responsible for buying valves. Send for your copy of DH1285.



Re-Grinding Type
for occasional throttling service



Semi-Plug Type
for frequent throttling service



Full-Plug Type
for severe throttling service

READING-PRATT & CADY

MANUFACTURERS OF
READING CAST STEEL VALVES AND FITTINGS • PRATT & CADY BRASS AND IRON VALVES
D'ESTE AUTOMATIC REGULATING VALVES

Reading, Pa. • Atlanta • Boston • Chicago • Denver • Houston • Los Angeles • New York • Philadelphia • Pittsburgh • San Francisco • Bridgeport, Conn.

ACCO

READING-PRATT & CADY DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

In Business for Your Safety

HAPPY PUMPERS

ASSURE *Greater* EFFICIENCY *with* *Dependable* DIAMOND CHAINS

Until the supply of men and materials returns to normalcy, you will appreciate more than ever the dependability of Happy Chain Driven Pumpers. The factors controlling performance, with minimum "shut-down" time, are engineered into every Happy Pumper we build.

Let a Happy sales representative discuss with you the advantages of Chain Driven pumping equipment over other types.

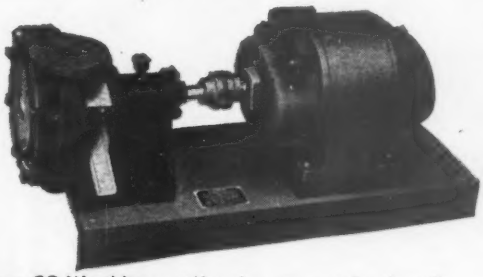
Rubber Belting
Leather Belting
V Belts
V Belt Sheaves
Happy Pumping Units
Power Transmission Equipment

The
HAPPY COMPANY
Formerly **HAPPY BELTING COMPANY**
TULSA, OKLAHOMA

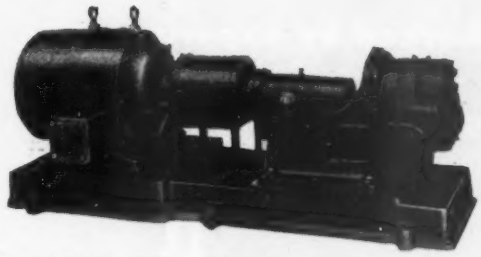
BRANCH OFFICES:

Seminole	Oklahoma
Smackover	Arkansas
Odessa	Texas
Kilgore	Texas
Pampa	Texas
Salem	Illinois
Wichita	Kansas
Ellinwood	Kansas

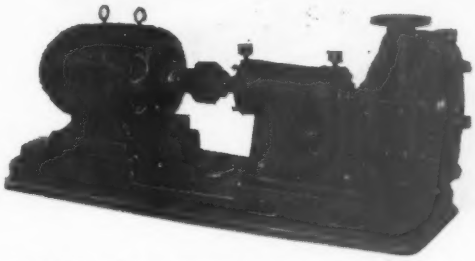
PUMPING CORROSIVE LIQUIDS



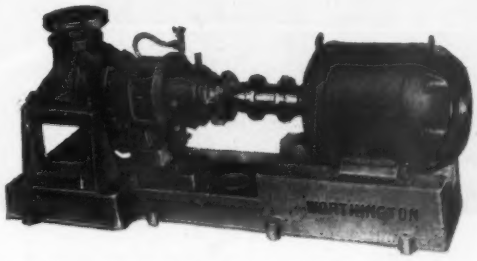
Type CG Worthite centrifugal pump . . . open impeller . . . capacities to 3000 GPM . . . heads to 150 ft. Bulletin W-350-B1F.



Type HBLC Worthite centrifugal pump . . . vertically split . . . capacities to 240 GPM . . . heads to 540 ft. Bulletin W-341-B7A.



Type CQ Worthite centrifugal general-purpose pump . . . capacities to 600 GPM . . . heads to 130 ft. Bulletin W-350-B3F.



Type HR centrifugal pump . . . capacities to 1800 GPM . . . heads to 900 ft. . . . temperatures to 800°F. . . . pressures to 750 PSI.

Worthington Corrosion-Resistant Centrifugal Pumps Cover the Broadest Range

Throughout its long pumping experience, Worthington has analyzed and solved many refinery corrosion and abrasion problems. As a result, the corrosive liquid or corrosive-abrasive slurry now troubling you can probably be successfully handled by a Worthington Centrifugal Pump.

Most corrosive conditions fall within the range of *standard* Worthington Chemical Pumps. Worthite has also proved economical to use in severe corrosive-abrasive conditions.

Worthite . . . a high-nickel, high-chromium, molybdenum, low-carbon alloy steel . . . is widely recognized as giving maximum resistance to both corrosion and abrasion. Worthite parts . . . valves, plugs, bars, etc. . . . may prove to be the answer to your difficulty.

To learn whether *there's more worth in Worthington*, discuss your problem with a Worthington Pump Application Engineer—without cost or obligation. Write today or telephone the nearest of our 36 branch offices. *Worthington Pump and Machinery Corporation, Harrison N. J.*

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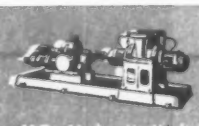
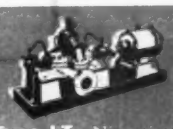
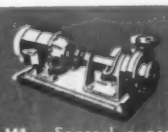
WORLD'S LARGEST MANUFACTURER OF PUMPS



Type HD. Hydraulically balanced for refinery process work at temperatures up to 850°F. and pressures up to 550 p.s.i., with the use of suitable materials. Capacities up to 3200 g.p.m., at heads up to 700 ft.



Type LT. Nine sizes. Capacities to 2500 g.p.m. Developed heads to 900 ft. Horizontally split case for temperatures up to 600°F. and pressures to 400 p.s.i.



Type HL. Several construction arrangements permit flexibility in application. Designed for temperatures up to 225°F., or higher with water-jacketed stuffing box. Capacities up to 1600 g.p.m., heads to 500 ft.

THE BECKMAN IR2 SPECTROPHOTOMETER

BECKMAN INFRARED SPECTROPHOTOMETRIC equipment is widely recognized for its important contributions to the success of the war-urgent butadiene and aviation gasoline programs. This equipment, developed by Beckman engineers working in close cooperation with leading petroleum scientists, made possible for the first time the accurate and rapid process control so essential to full refining efficiency.

It is a significant fact that there have been more Beckman Infrared Spectrophotometers built than all other makes combined. And so successful was the original Beckman Infrared instrument that its far-reaching advancements have now been incorporated into a new and even more versatile instrument, extending the advantages of infrared analytical and control methods to much broader fields of application. This new instrument is the Beckman IR2. Into its design Beckman engineers have embodied the ideas, user-suggestions and first-hand experience gained from the pioneer work in butadiene and 100-octane applications.

There is no other instrument like the IR2, because no other instrument has such a background of valuable experience behind it. It incorporates sweeping advancements in design and construction for maximum versatility, accuracy, speed and convenience. Check over the many unique features. Note how important these improvements are. Make a point by point comparison with conventional equipment and see how much more the Beckman IR2 provides.

Our technical staff will gladly supply more complete details on the Beckman IR2 instrument. A letter, wire or phone call will place this information in your hands without delay. *Beckman Instruments, National Technical Laboratories, South Pasadena 26, California.*

A FEW IR2 ADVANCEMENTS

HERMETICALLY SEALED
No costly air-conditioning required. Unaffected by humidity or atmospheric contamination.

INTEGRAL AMPLIFIER
No extra amplifier needed for recording. IR2 can be direct-connected to standard recorder.

DIRECT-READING SCALES
Wavelength scale reads directly without curves, charts or computations.
Per cent Transmission scale also reads directly.

CONSTANT RADIATION
Photoelectronic regulator maintains radiation constant within 0.1%.

ZERO DRIFT ELIMINATED
Greater accuracy; simpler, faster operation.

FALSE ENERGY ELIMINATED
Negligible stray light effects assure increased accuracy.

GALVANOMETERS ELIMINATED
Beam-modulation, bolometer and electronic amplifier eliminate vibration, temperature and non-linearity difficulties associated with galvanometers.

TEMPERATURE CORRECTIONS ELIMINATED
Entire instrument thermostated.

UNUSUAL VERSATILITY
Light sources, cell holders and other elements are interchangeable for a wide range of applications on gases, liquids and solids.

The above are only a few of many IR2 innovations. Write for full details.

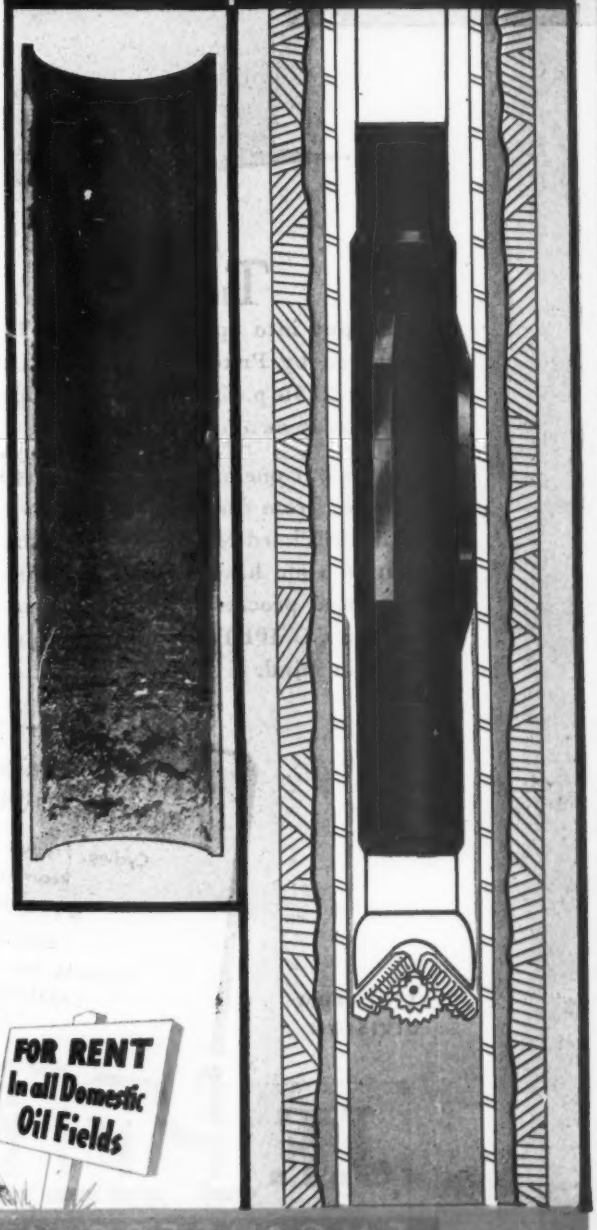
BECKMAN INSTRUMENTS CONTROL MODERN INDUSTRIES

HERE'S PROOF

that No Well is Properly Completed until the Casing has been Scraped

This casing is from a well that never was properly completed.

See how it could have been done with a *BAKER* Casing Scraper



If you have ever been "all burned up" because a packer or swab would not pack off—or a cement retainer set prematurely and could not be lowered past a certain point in the casing or liner—you probably were confronted with the condition pictured at the right.

Here is a section of liner which was split to determine the reason for premature setting of a cement retainer. The reason is obvious and this photograph also reveals why packer or retainer slips will not hold properly because they become packed with cement or mud that is clinging to the walls of the pipe.

BAKER ROTARY CASING SCRAPERS should be run behind the bit every time you drill out cement, to completely remove the sheath of cement left by the bit—to remove the burrs left from gun-shot holes—to remove any scale from the "working surface" of your casing, leaving it clean and smooth to its full I.D. It is just that easy to KNOW that all future down-hole work can be performed safely and quickly, with no damage to packer or swab rubbers—to KNOW that no obstructions remain to interfere with later production or remedial operations.

YOUR DRILLING CREWS RUN IT

The time to use a Baker Rotary Casing Scraper is while the equipment is still up and the crew is on hand. No extra run is necessary if you run the Casing Scraper as a "follow-up" to the bit when drilling out cement—no service man is required.

For complete information ask any Baker representative, or look for Product No. 620 on Page 357 of your Baker (or Composite) Catalog.

BAKER OIL TOOLS, INC.

Houston — Los Angeles — New York

REASONABLE RENTAL RATES • YOUR CREWS CAN RUN IT SUCCESSFULLY

BAKER Rotary Casing Scraper

THE world's largest Pressure Maintenance Recovery Plant has recently been put into operation on the Texas Gulf Coast. Designed, engineered and constructed by Pritchard, this plant processes 350,000,000 cubic feet per day of wet gas at 2250 p.s.i., producing propane, normal and isobutane, isopentane, motor gasoline, kerosene and gas oil.

This is but one of the many plants in the petroleum, gas and petro-chemical industries handled from the drawing boards to actual operation by the *Petroleum Division* of J. F. Pritchard & Co. On these contracts, much money and months of specs-to-completion time have been saved through Pritchard's intimate working knowledge of advanced processing techniques and broad experience in their applications. Turn this proven COMPETENCE to your profit—bring PRITCHARD into the PLANS you have in mind.

DESIGN . . . ENGINEERING . . . CONSTRUCTION and COORDINATION of OIL FIELD PROCESSES

Cycling, Pressure Maintenance, High and Low Pressure Recovery Systems, Crude Stabilization.

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